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INFORMATION CIRCULAR

MULTIPLE-SHIFT MECHANICAL MINING IN SOME BITUMINOUS-COAL MINES. PROGRESS REPORT 3

BY

ALBERT L. TOENGES AND EARL R. MAIZE

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By Albert L. Toenges 2/ and Earl R. Maize 3/

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This paper is the third of a series[4/] that describes some methods and practices of mining coal mechanically where operations are conducted on more than one shift. The mining of coal by means of mechanical devices has emphasized the need for continued study of the relationship of these devices to existing physical conditions and to planning of the operations for increased safety and economy. The purpose of this investigation is to study the operations of different types of mechanization used in mines under various systems of mining and physical conditions to reach conclusions as to the safest and most economical methods and practices of mining. Physical conditions vary in different and in the same mining districts and determine, together with economical conditions, the systems of mining and the types of mechanical loading equipment used. The information presented in this paper

4/ Toenges, Albert L., and Anderson, Robert L., Multiple-shift Mechanical Mining in Some Bituminous-coal Mines. Progress Report 1: Bureau of Mines Inf. Circ. 7014, 1938, 56 pp.
Toenges, Albert L., and Jones, Frank A., Multiple-shift Mechanical Mining in Some Bituminous-coal Mines. Progress Report 2: Bureau of Mines Inf. Circ. 7067, 1939, 58 pp.

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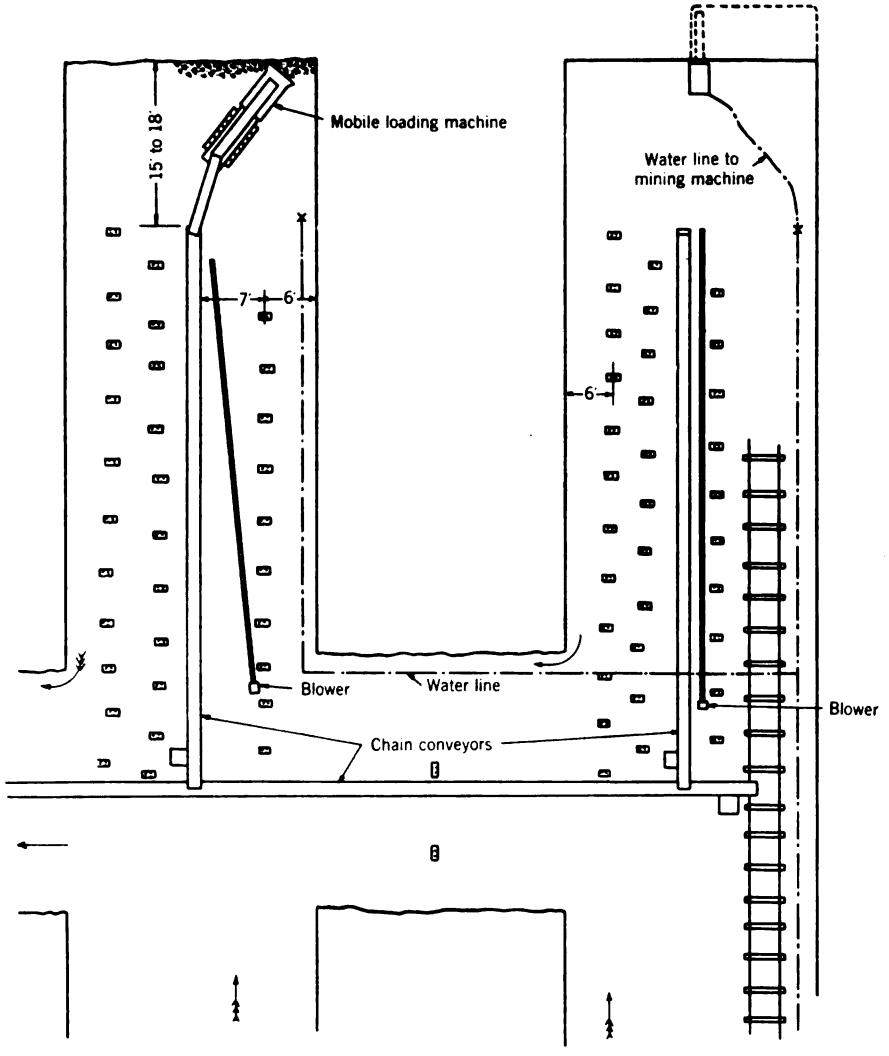
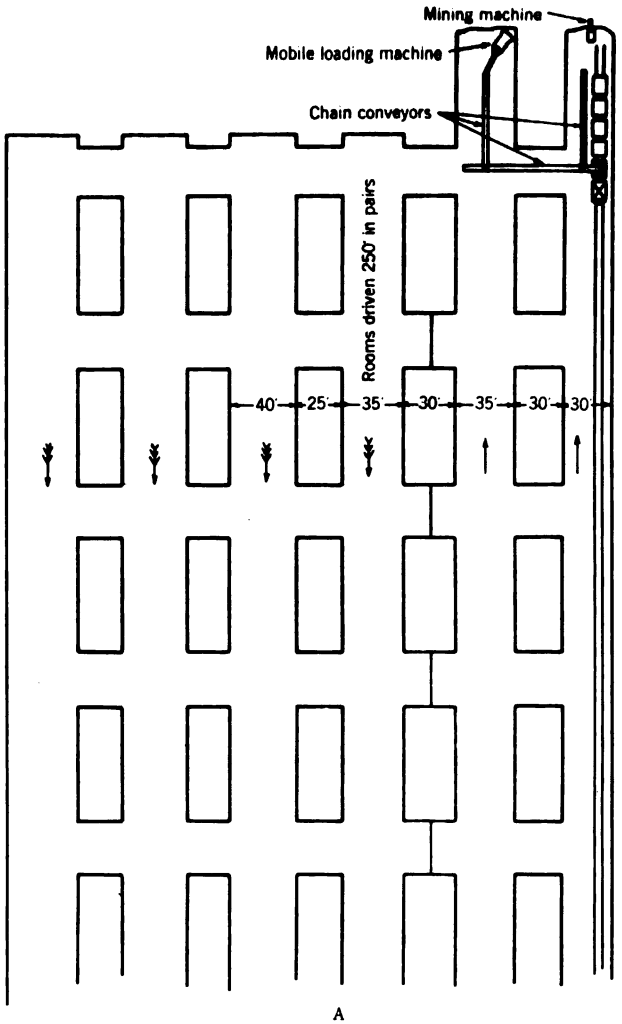


B
Details of advancing rooms



A

Figure 1.—Mining system at mine 26.

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may be helpful to operators and others who may contemplate installing a mechanical mining system.

Mobile loading machines were used in the mines described in this report, except at two mines, in which conveyors were used on long faces. In computing the operating data of mines not totally mechanized, employees not working directly on production have been charged to output from mechanized sections in proportion to the percentage of coal mined by mechanized methods. The operating data are for an average working day, as the number of men working on idle days varies greatly in different mines. Commendable safety practices and those not considered safe are dealt with in the general discussion of this paper.

ACKNOWLEDGMENT

The information used in preparing this paper was obtained through the courtesy and cooperation of the officials of the companies whose mines are described. The consent of executives was obtained to publish the data, and their accuracy was verified.

DESCRIPTION OF MINES

Mines have been numbered beginning with 26, because the last mine described in Progress Report 2, Information Circular 7067, was 25.

Mine 26

This mine, which produces 475 tons of coal daily in two loading shifts, is 100 percent mechanized. It is opened by two slopes to the coal bed, which averages 50 inches in thickness and contains an 8-inch band of impurities 12 to 14 inches above the bottom. The roof is hard, sandy shale and the bottom is sandstone. The bed is variable in height and contains many local dips.

Mining Method

The mine is developed by the room-and-pillar system. At the time of the visit a set of six continuous rooms was being developed. The first two rooms were 30 and 35 feet wide, respectively, separated by a 30-foot pillar. The remaining four rooms were 35 to 40 feet wide with 25-foot pillars between rooms. (Refer to fig. 1, A.)

The rooms are advanced in pairs 200 to 250 feet, the limit of the conveyors; then the equipment is moved to the adjoining two rooms. This procedure is continued until all six rooms have been advanced; then the cycle is repeated.

The coal is cut by a shortwall mining machine and loaded by a crawler-mounted, mobile, loading machine onto a chain conveyor in the center of the room. This chain conveyor transports the coal to a cross conveyor in the last crosscut. The cross conveyor discharges the coal into mine cars on the haulageway. The track is placed in the outside or No. 1 room. As the coal

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passes over the conveyors, two men on each shift remove as much of the impurities as possible. The equipment used for advancing the rooms is as follows:

1 mobile loader
1 mining machine
1 portable electric drill
3 chain conveyors
2 auxiliary blowers

This equipment is operated by an 11-man crew classified as follows:

1 loader operator
1 loader helper
2 mining-machine men
1 trimmer
2 shooters and drillers
1 pan man
2 slate pickers
1 motorman

The face of one room is prepared while the coal of the other room is being loaded. Cutting is done in the bottom of the bed by a shortwall mining machine equipped with a 6-foot cutter bar using tipped bits. Water is used on the cutter bar to allay the dust. Approximately seven cuts per day are made in the two rooms. Nine holes are drilled - four above the middle band and five below. Each hole is charged with two sticks of permissible explosives stemmed with rock dust and fired simultaneously by means of a 50-shot push-down generator. The coal produced per pound of explosives averages 7.72 tons.

The mine is ventilated by a 36-inch centrifugal fan operated exhausting. The main-line haulage is on the return air circuit, and the secondary haulage and the producing equipment are on the intake air circuit. The working faces are ventilated by auxiliary fans at the last open crosscut.

Three rows of timbers are set in each room, as shown in figure 1, B, and 10.9 tons of coal are produced per prop used.

Mine cars ranging in capacity from 1,500 to 2,700 pounds are hauled in 20-car trips on the main line by an electric trolley locomotive. Trips of five cars are hauled by the relay locomotive to and from the main-line sidetrack to the loading point.

The classification of men employed is as follows:

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Classification	Day shift	Night shift	Total
Underground:			
Loading-machine operator and helper.	2	2	4
Shooter and driller	2	2	4
Mining-machine men	2	2	4
Pan man	1	1	2
Slate pickers	2	2	4
Trimmer	1	1	2
Motorman	1	1	2
Total on mechanized units	11	11	22
Other underground:			
Relay locomotive operator	2	2	4
Main-line locomotive	2	-	2
Trackman	1	-	1
Electrician	2	1	3
Bottom man	1	-	1
Supervision	2	1	3
Total other underground	10	4	14
Total underground	-	-	36
Surface:			
Tipplemen	3	-	3
Yard men	2	-	2
Washery men	2	-	2
Belt men	2	-	2
Car-repairmen	2	-	2
Hoisting engineer	1	-	1
Blacksmith and helper	2	-	2
Superintendent	1	-	1
Total surface	15	-	15
Total employees	-	-	51

A time study of the loading operations made over a portion of the shift may be summarized as follows:

Operation	Percent of shift
Loading	51.3
Squirming (getting into loading position)	14.9
Waiting for cars	20.4
Mechanical and miscellaneous delays	9.5
Moving to new place	3.9
	100.0

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SUMMARY

Mechanization of mine, percent	100
Average daily production (raw coal), tons	475
Number of loading machines	1
Number of loading machine shifts per day	2
Average number of men per unit per shift	11
Man-shifts per day on mechanized units	22
Average tons per day per man on mechanized units	21.6
Total employees underground	36
Average tons per day per man underground	13.2
Total employees, surface and underground	51
Average tons per day per man employed	9.31

Mine 27

The production of the mine is 1,510 tons per day; 50 percent is loaded mechanically with mobile loading machines. The coal bed is opened by a three-compartment shaft 365 feet deep and a slope 1,600 feet long. The slope is used for lowering men and materials. The fan is on the surface at the slope, which is the intake airway of the mine. The coal bed is comparatively level, contains several partings and a hard-shale middle band, and ranges in thickness from 32 to 85 inches. The character of the bed is noted in the following sections.

		Inches
	Coal	36
	Bony	1
1.	Coal	4
	Middle band	6
	Coal	25
		72
	Coal	38
2.	Middle band	6-1/2
	Coal	40
		84-1/2

At places the lower bench of coal is absent. The roof is shale and the bottom sandy fireclay.

Mining System

The room-and-pillar system of mining is used, and pillars are not extracted. The mine is developed by driving sets of four main entries in opposite directions from the shaft. These entries comprise two sets of two entries. The pairs of entries are separated by a pillar 50 feet wide broken only at cross entries. Crosscuts between entries in pairs are turned on 60-foot centers. All entries are driven 14 to 30 feet wide. Cross entries from which rooms are driven are turned to the right and left from the main entries at intervals of 600 feet. Rooms are turned to the right and left at right angles from these cross entries.

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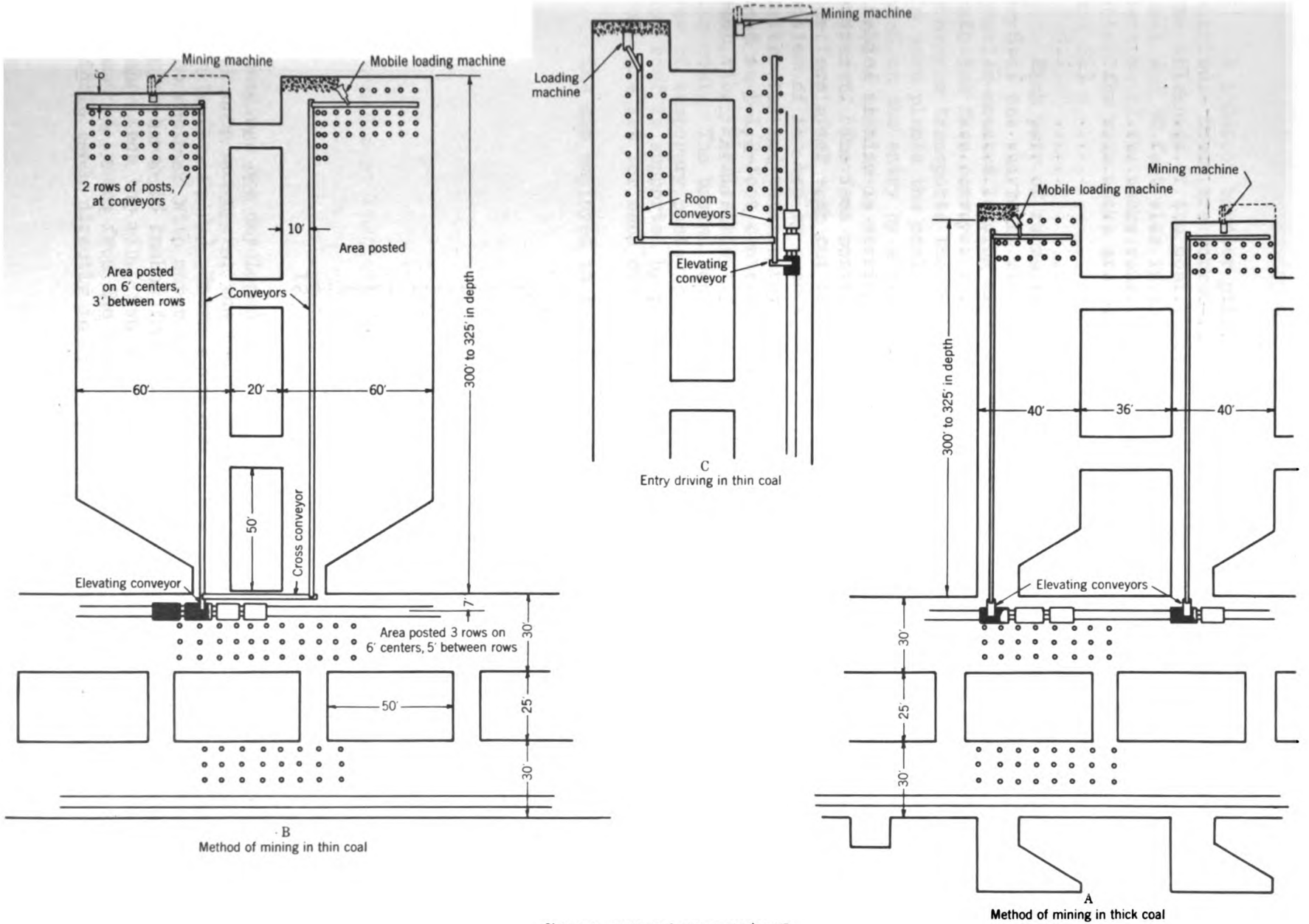

Figure 2.—Method of mining at mine 27.

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A 150-foot barrier pillar is left between the first room and the main entries. Rooms are worked in pairs, and the width of the rooms depends on the thickness of the coal. Rooms are usually driven 60 feet wide in thin coal and 40 feet wide in thick coal. Rooms are necked 16 feet wide, and the centers of the necks range from 36 to 76 feet, depending on the manner in which the room necks are widened after the second cut. (Refer to fig. 2, A and B.)

Each pair of rooms is equipped with two room conveyors, two face conveyors, one shortwall mining machine, one portable electric drill, and one crawler-mounted loading machine. The coal is loaded by the loading machine onto the face conveyor that discharges the coal to the room conveyor. This conveyor transports the coal to cars in the entry. (Refer to fig. 2, A.) In some places the coal from two rooms is transported to a common loading head on the entry by a cross conveyor. (Refer to fig. 2, B.) While the loading machine is working in one room, the face of the adjacent room is prepared. The face conveyor is moved 6 feet forward to within 16 feet of the face after each cut of coal has been loaded. The coal is cut in the bottom of the bed by a shortwall mining machine equipped with a 6-1/2-foot cutter bar and water sprays. Holes are drilled above and below the middle b band on 5-1/2-foot centers. The side holes are placed about 18 inches from each rib. Permissible explosives fired electrically are used to break down the coal. The broken coal is sprinkled with water while being loaded. One row of temporary posts is set across the face during the loading operation. The roof is supported by posts set on 6-foot centers across the face; two rows are set for each cut advance of the face.

The men employed in two rooms are as follows:

1	loader operator
1	loader helper
1	cutting-machine man
1	cutting-machine helper
2	drillers and shotfirers
1	timberman
2	conveyor men
1	car trimmer
1	slate picker
1	face boss
12	

Headings are developed by loading the coal either directly into mine cars or onto conveyors; the latter system is usually employed in thin coal. (Refer to fig. 2, C.) Entries are cut in the bottom with a shortwall mining machine equipped with water sprays. Six equally spaced holes are drilled in the upper bench 18 inches from the top, and the two side holes are placed 18 inches from the rib. Two additional holes are drilled above the middle band and 18 inches from the rib. Four holes are drilled a few inches below the middle band, directly in line with the upper four center holes. The holes

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are charged with permissible explosives and fired electrically. A complete round is fired at one time with a multishot blasting unit. Loading operations are conducted in one entry while the adjacent one is prepared. Each heading is advanced approximately two cuts per shift, or about 24 feet per day.

One loading machine operates two shifts per day and two other loading machines operate one shift per day. The classification of men on the machine operating two shifts per day loading into mine cars is as follows:

1 loading-machine operator
1 loading-machine helper
1 mining-machine operator
1 mining-machine helper
2 drillers and shooters
1 timberman
1 trackman
1 motorman
1 triprider
10

A study of the loading operation in headings made over a portion of the shift is summarized as follows:

Loading directly into mine cars

	Percent of shift
Loading	44.8
Squirming (getting into loading position)	13.7
Car change	17.4
Waiting for cars	8.4
Moving to new place	15.7
	100.0
Number of cars loaded: 86.	

Loading onto conveyors into cars (time at transfer station)

	Percent of shift
Coal moving into cars	1/61.5
Delays waiting for cars	27.9
Miscellaneous delays	10.6
	100.0
Number of cars loaded: 81.	

1/ Loading machine at face "squirmed" 38 percent of loading time.

	Percent
Loading at face	38.6
Squirm at face	22.9
	61.5

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Classification of employees during 24 hours is as follows:

Classification	Day shift	Night shift	Total
Underground:			
Loading-machine operators	2	2	4
Loading-machine helpers	2	2	4
Mining-machine operators	2	2	4
Mining-machine helpers	2	2	4
Drillers and shooters	4	4	8
Conveyor men	2	2	4
Car trimmer	1	1	2
Timberman	4	3	7
Trackmen	6	-	6
Slate pickers	1	1	2
Motormen	2	2	4
Brakemen	2	2	4
Employees chargeable to mechanized units	66 30	23	53
Other underground:			
Brushers	10	-	10
Bratticemen	1	-	1
Sprinkler and pipemen	1	-	1
Pumper	1	-	1
Electrician	2	-	2
Weighman	1	-	1
Supervision	4	2	6
Total other underground	20	2	22
Total underground chargeable to mechanized production	50	25	75
Surface:			
Tipplemen and surface	11	1	12
Total chargeable to mechanized production	61	26	87

SUMMARY

Mechanization of mine, percent	50
Average daily production from mechanized units, tons	755
Number of mechanized units	3
Number of mechanized-unit shifts per day	4
Average number of men per unit per shift	13.25
Man-shifts per day on mechanized units	53
Average tons per day per man on mechanized units	14.25
Total employees underground chargeable to mechanized units	75
Average tons per day per man underground	10.06
Total employees underground and surface, chargeable to mechanized production	87
Average tons per day per man employed	8.68

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Mine 28

This mine, which operates two shifts and produces an average of 4,880 tons of coal daily, is 100 percent mechanized. The coal bed ranges in thickness from 18 to 28 feet, dips 3-1/2 percent, and has an average cover of 300 feet. The coal is subbituminous in rank. Because of the high ash content of the upper portion of the bed, only the lower 10 feet is mined. The stratum above the bed is hard shale, which disintegrates rapidly when exposed and is protected by the roof coal. The stratum under the coal is soft fireclay, and 8 to 12 inches of coal is left to form a solid bottom. Thus the working places average about 9 feet in height.

Mining Method

The mine opening is a drift in the coal bed. The main entries comprise three headings driven down the dip. Submain entries are turned right and left in pairs at intervals of about 1,000 feet and are driven approximately on the strike of the bed. Panel or room entries are turned in pairs up the dip on about 400-foot centers. All entries are driven 12 to 14 feet wide on 50-foot centers.

Rooms are developed both to the right and left 24 feet wide on 40-foot centers off the panel entries. Pillars are not extracted. Barrier pillars for main entries average about 60 feet in thickness, and those for submains are approximately 40 feet thick. The rooms of one panel are not connected with those of adjacent panels, and barriers around panels range in thickness from 20 to 40 feet. When panels are completed they are sealed with heavy, incombustible stoppings.

Under a system recently inaugurated submain entries are being driven in triplicate, and panel entries, also in triplicate, are turned up the dip from the submains. Figure 3, A, shows the method of developing these panels. It will be noted that panel entries comprise five headings for each group of six rooms and are then reduced to three headings for a distance of about 60 feet, or the distance between room barriers. A 50-foot barrier is left between each set of six rooms to prevent squeezes that may develop if the weight of the overburden is carried over to the adjoining set of rooms. A plan using seven panel entries and a section of seven rooms is contemplated.

The mine is ventilated by a force fan on the surface. Return air travels the haulageways.

The coal roof is strong, and very little timber is used for roof support.

The coal in rooms is cut in the bottom of the bed by means of a short-wall mining machine equipped with a 9-1/2-foot cutter bar; water is used on the cutter bar. Jack pipes for the cutting machine have been replaced by wedge hooks driven in holes in the rib and face. Nine 3-1/4-inch holes are drilled by a rubber-tired, mounted, auger-type electric drill. The coal is blasted by Cardox. Approximately 1.68 tons of coal is produced per pound of carbon dioxide. Water is used to allay dust following blasting and during

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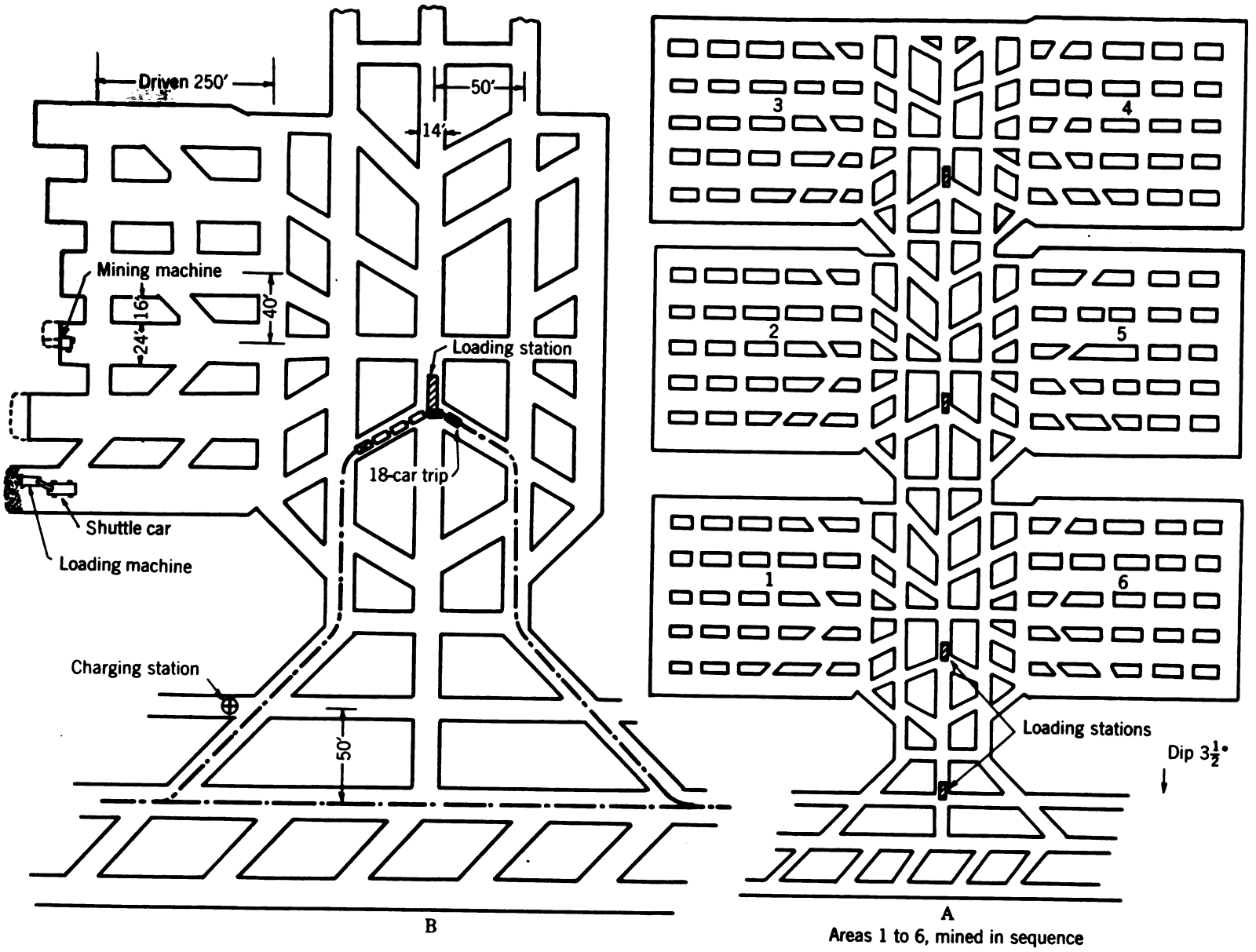

Figure 3.—Mining system at mine 28.

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loading when it is deemed necessary. The coal is loaded by crawler-mounted loading machines into shuttle cars. An average of about 682 tons is loaded per shift by each loading machine. Shuttle cars transport the coal to a loading point in the middle entry, where it is transferred to mine cars. (Refer to fig. 3, B.) The average load per shuttle car at the time the mine was visited was 7.12 tons. Two shuttle cars are used with each loading machine, and the maximum round-trip haul is 800 feet. Each shuttle car has two sets of batteries, one set being used per shift. The charging station is placed near the entrance to each panel. The average crew for one shuttle-car section is:

2	machinemen
2	drillers
2	shotfirers
2	shuttle-car operators
2	loading-machine men
1	loading-head operator
1	locomotive operator
1	mechanic
3	utility men
1	sprinkler
1	foreman
18	

In development work the cutting is done by standard shortwall mining machines equipped with an 8-1/2-foot cutter bar. An electric, post-mounted, auger-type drill is employed for drilling. The coal is loaded by crawler-mounted, mobile loading machines into mine cars averaging 2.85 tons per car. A machine loads an average of 197 tons per shift. The crew for development work comprises:

2	loading-machine men
1	mining-machine man
1	driller
1	shotfirer
1	locomotive operator
1	brakeman
1	trackman
8	

Electric power is purchased, and about 4.8 kilowatt-hours is consumed per ton of coal produced.

The following is the classification of labor employed in a 24-hour period:

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Classification	Day		Night		Total
	Large unit, rooms	Small unit, development	Large unit, rooms	Small unit, development	
Underground:					
Loading-machine men	6	4	6	4	20
Drillers	6	2	6	2	16
Shotfirers	6	2	6	2	16
Shuttle-car operators	6	-	6	-	12
Machine men	6	2	6	2	16
Locomotive operators	3	2	3	2	10
Mechanics	3	-	3	-	6
Utility men	9	-	9	-	18
Sprinklers	3	-	3	-	6
Foremen	3	-	3	-	6
Brakemen	-	2	-	2	4
Trackmen	-	2	-	2	4
Loading-head operators	3	-	3	-	6
Total chargeable to mechanized units	54	16	54	16	140
Other underground:					
Mine examiner	1		-		1
Motor-generator attendants	2		2		4
Laborers	2		5		7
Wireman	1		-		1
Supplyman	1		-		1
Ventilation men	2		-		2
Trackmen	2		1		3
Locomotive operators	9		9		18
Brakemen	7		7		14
Dispatchers	1		1		2
Mine foreman	1		-		1
Total other underground	29		25		54
Total chargeable to mechanized production					194
Surface:					
Tipplemen	21		21		42
Foreman	1		-		1
Bath-house attendant	1		2		3
Blacksmiths	2		-		2
Mechanics	1		1		2
Electricians	1		1		2
Car rapairman	1		-		1
Supplymen	1		1		2
Laborers	1		1		2
Clerks	3		-		3
Mining engineer	1		-		1
General superintendent	1		-		1
Total surface	35		27		62
Total employees					256

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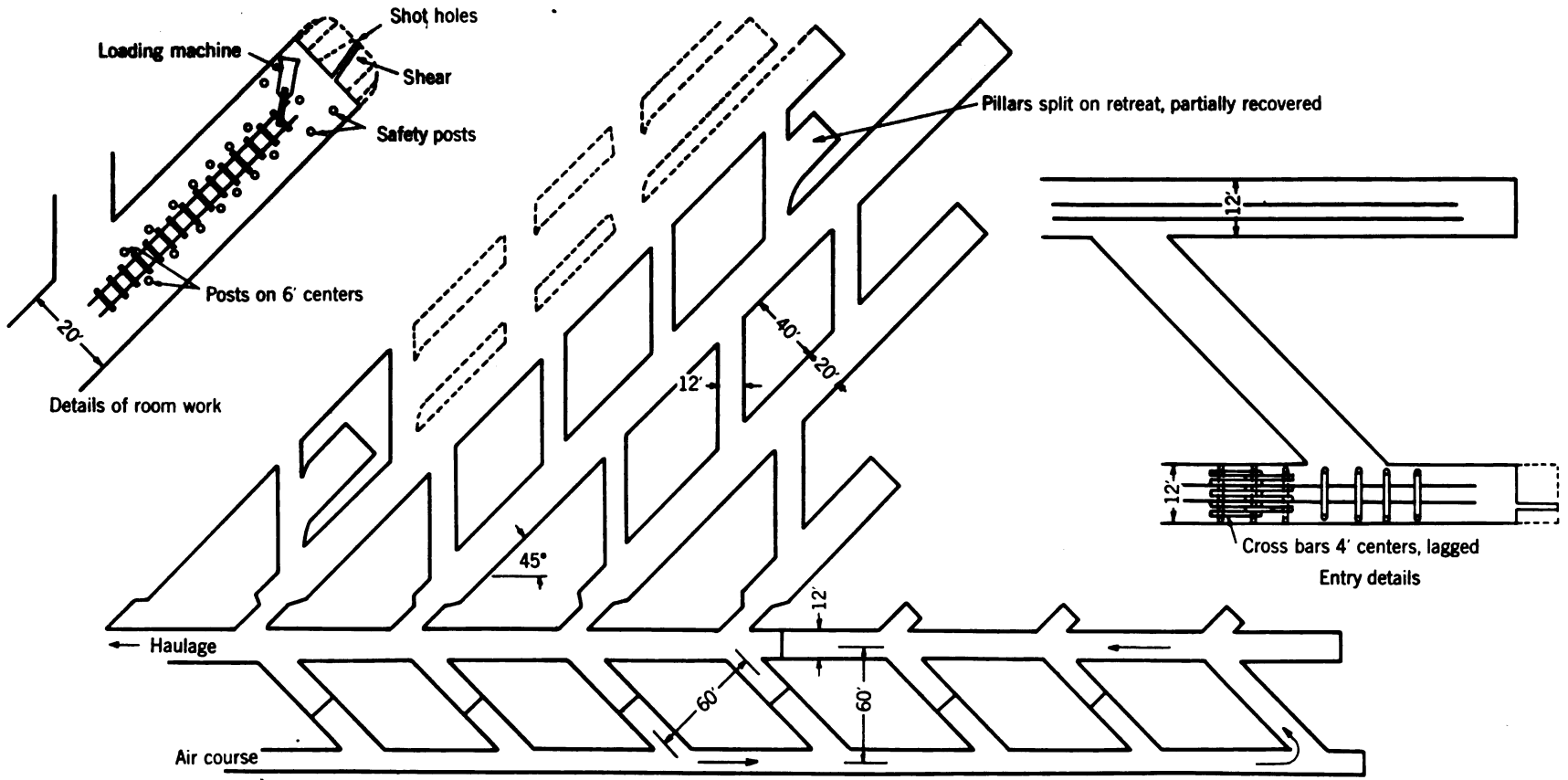

Figure 4.—Method of mining at mine 29.

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SUMMARY

Mechanization of mine, percent	100
Average daily production from mechanized units, raw coal, tons	4,880
Number of loading machines	5
Number of loading-machine shifts per day	10
Average number of men per unit per shift, large unit, rooms	18
Average number of men per unit per shift, small unit, development	8
Man-shifts per day on mechanized units	140
Average tons per day per man on mechanized units, large units	37.9
Average tons per day per man on mechanized units, small units	24.8
Average tons per day per man on mechanized units, combined units	34.7
Total number of employees underground	194
Average tons per day per man underground	25.15
Total number of employees, surface and underground	256
Average tons per day per man employed	19.06

Mine 29

The coal bed at this mine is opened by a slope. The first part of the slope is 3,600 feet long on a dip ranging from 2° to 5°, and the second part is 3,400 feet long on a dip ranging from 3° to 8°. The first part of the slope is in a coal bed 87 feet above the bed now being worked. At present operations in the upper bed have been discontinued. The lower bed is opened by a rock slope from the upper bed, and the slope continues in the lower bed.

The coal bed is 8-1/2 feet thick. The stratum above the bed is soft shale, and the 1 foot of coal is left as roof to protect the soft shale from the effects of weathering. The bottom is sandy shale. The bed pitches 4-1/2 percent and has an average cover of 1,000 feet.

The mine is 100 percent mechanized, and two track-mounted and two crawler-mounted mobile loading machines are used. One track-mounted machine is worked two shifts per day. The machines load an average of 1,335 tons of raw coal per day.

Method of Mining

The main entries comprise three headings. Room entries are turned right and left from the main entries in pairs of 500- to 600-foot centers. Room entries, main entries, and crosscuts are driven 12 to 14 feet on 60-foot centers. Rooms are turned on an angle of 45° from the entry and driven 20 to 25 feet wide on 60-foot centers and 300 to 400 feet long. (See fig. 4.) Where possible, the room pillars are partly recovered by splitting on the retreat from the room.

The coal is cut in the top and also sheared by track-mounted machines using water on the cutter bar. These machines are equipped with 9-foot cutter bars. One cutting machine operates two shifts per day. Two cutters and two drillers are assigned to each machine, and one shotfirer is assigned to each cutting-machine crew. Usually five or six holes are drilled per

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room with either a track-mounted, auger-type electric drill or by the same type of drill mounted on a cable-reel locomotive. The coal is blasted by means of black powder and fuse at the end of shift. The cycle of mining is as follows: Timber and track work, cut, drill, blast, and load.

Rooms are usually timbered with two rows of posts on 6-foot centers, one on each side of the track, or more if necessary, and safety posts are used at the face where needed. A 4- by 6- by 27-inch cap is used on each post. Approximately 8.5 tons of coal is produced per prop. Entries are well-timbered with three-piece lagged sets placed on 4-foot centers when the top coal is too fragile to support the roof.

The cars, 3.5-ton-capacity, steel, end-dump type, are transported by cable-reel locomotives to the loading machines in trips of six. One car at a time is loaded by crawler-mounted machines and two cars at a time by track-mounted machines. The cars are switched at the nearest breakthrough, and the average one-way car change is 100 feet. A track-mounted loading machine is used in entries and loads the coal directly into mine cars. After a trip of six cars has been loaded the cars are transported to the slope parting. Twelve cars comprise a slope trip. These are hoisted to the tipple by two electric 150-horsepower hoists.

The average crew for the two types of loading machines is as follows:

	Rooms, crawler-mounted loading machines	Entries, track-mounted loading machines
Loading-machine men	2	2
Locomotive operator	1	1
Brakeman	1	1
Trackmen	1	2
Timberman and faceman	1	1
	6	7
Average tons per shift per loading machine	207.0	305.2

Classification of labor used per day is as follows:

Classification	Day shift	Night shift	Total
Underground:			
Loading-machine crews	26	7	33
Mining-machine crews	4	4	8
Shotfirers (between shifts)	1	1	2
Total chargeable to mechanized units	31	12	43
Other underground:			
Main-line motormen	4	1	5
Engineer (hoistman)	2	1	3
Trip rider	2	1	3
Trackmen	6	-	6
Timbermen	6	-	6
Laborers	3	5	8

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Classification	Day shift	Night shift	Total
Other underground (Cont'd.):			
Nippers	1	1	2
Ventilation (bratticemen)	1	-	1
Safety man	1	-	1
Fire boss	1	-	1
Pumpers	2	-	2
Electricians and mechanics	3	3	6
Mine foremen	2	1	3
Total other underground	34	13	47
Total underground	65	25	90
Outside:			
Foremen	2	-	2
Cleaning plant and tipple	14	-	14
Watchman	1	-	1
Main hoistman	1	-	1
Car repairman	1	-	1
Blacksmith	1	-	1
Laborers and rockmen	11	-	11
Electrician and mechanics	6	-	6
Total outside	37	-	37
Total employees			127

Summary for Average Working Day

Mechanization of mine, percent	100
Average daily production, raw coal, tons	1,335
Number of loading machines	4
Number of loading machine-shifts per day	5
Average number of men per unit per shift	8.6
Man-shifts per day on mechanized units	43
Average tons per man per day on mechanized units	31.0
Total number of employees underground	90
Average tons per man per day, underground	14.8
Total employees, surface and underground	127
Average tons per day per man employed	10.52

Mine 30

The coal bed at this mine ranges from 4 feet 6 inches to 6 feet in thickness. The stratum above the bed is sandy shale, and the bottom varies from sandy shale to fireclay. The mine is developed from a two-compartment shaft 365 feet deep. The average daily production, which is 1,836 tons, is hoisted through this shaft in cars on self-dumping cages by a 600-horsepower electric hoist.

Mining Method

The room-and-pillar system of mining is used, and ordinarily pillars are not extracted. Entries are driven 12 to 16 feet wide on 50-foot centers. Cross entries are turned off the main entries on an average of 3,200 feet

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apart, and room entries are turned off the cross entries at intervals of 500 feet. Rooms are turned at right angles both to the right and left off the room entries on 50-foot centers. Rooms are necked 12 feet wide by 18 feet long and then driven 34 to 40 feet wide to a depth of 250 feet. A room panel usually comprises 56 rooms, 28 on each side of the entries. A barrier pillar 150 feet wide is left between the cross entry and the first rooms of a panel. The roof of the haulageway is brushed, where the height of coal will not allow 5-foot clearance above top of rail.

The track is in the center of the room, and rooms are timbered with 4 to 6 rows of posts placed on 5 to 6-foot centers, depending on the condition of the roof. Safety posts are set as required. Approximately 7.41 tons of coal is produced per prop used. Entries are timbered where necessary with three-piece sets.

The coal is cut in the bottom of the bed with shortwall machines equipped with 7-foot cutter bars, and the face is then drilled with a portable, electric, auger-type drill. The holes are charged with pellet powder and fired with fuse by shotfirers after shift when the men are out of the mine, except in one section of the mine, where the coal is loaded onto conveyors by a mobile loading machine. In the section where conveyors are used the holes are charged with permissible explosive and fired electrically.

All of the production is loaded mechanically with 10 crawler-mounted, mobile, loading machines. The machines have a rated capacity of 2 tons per minute. The mine comprises four sections - three sections each equipped with three loading machines in which the coal is loaded into cars, and one section in which the coal is loaded by a mobile loading machine onto shaking conveyors, which transport the coal to mine cars on the entry.

The crew assigned to each loading machine does all the work required to produce the coal for that machine in a mine-car section and is as follows:

1 loading-machine operator
1 loading-machine helper
1 cutting-machine operator
1 cutting-machine helper
1 tracklayer
1 timberman and faceman
1 motorman
1 brakeman
8

In the sections where loading is into mine cars, three loading machines comprise a group, and five men are employed at night for each group. These men reclaim material, lay track where necessary, and finish cutting and preparing places, including blasting, for the day shift. Each loading machine is serviced by a cable-reel gathering locomotive. The cars, which are the end-dump type with steel body and wood ends, have an average capacity of 2.1 tons and are loaded one at a time. Loaded and empty trains are transported to and from the working sections and the main-line sidetracks by relay

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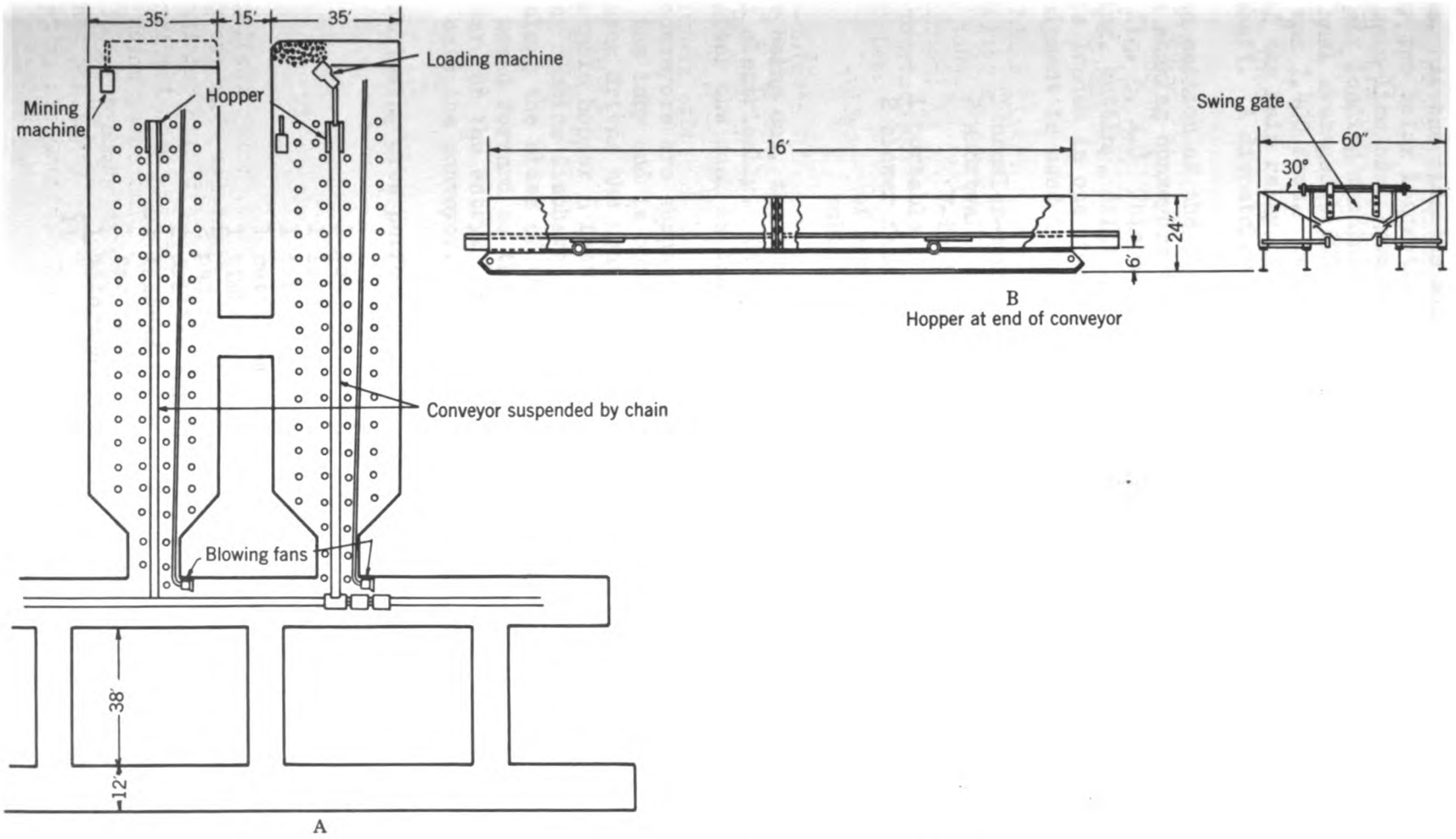

Figure 5.—Method of mining in low coal at mine 30.

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locomotives. At the time the mine was visited, four loading machines were serviced by two relay locomotives, and the average haul was 1,900 feet one way. The main-line haul from these sections to the shaft was 13,200 feet. The other six loading machines are serviced by four relay locomotives, and the relay haul averaged 6,800 feet. The distance from this relay parting to the shaft was 7,400 feet. Two 15-ton, main-line, trolley locomotives, one for each of the main relay partings, transport 25 to 75 car trains to the hoisting shaft. A dispatcher directs the movement of the trains.

In the section of the mine where the coal is loaded by the loading machine onto shaking conveyors the bed averages 4 feet 6 inches in thickness. (Refer to fig. 5, A.) This section comprises two rooms, and the mining cycle of timbering, cutting, drilling, blasting, and loading is continuous. While the coal is loaded in one room, the other room is being prepared. The following equipment is used in this section:

1 crawler-mounted loading machine.
2 shortwall cutting machines equipped with 7-foot bar.
1 portable electric auger drill.
2 blower fans that furnish 2,300 fubic feet of air per minute through 16-inch tubing to each working place.

After being cut, the face is drilled and blasted with permissible explosives fired electrically. The auxiliary fans are used to remove the smoke from the room after the coal is blasted.

The conveyors are suspended by chains from posts set on each side of the conveyor; the inby end is operated on rollers. A 20-horsepower, direct-current motor drives the conveyor. The inby section of the conveyor passes under a movable hopper 5 feet wide and 16 feet long. (Refer to fig. 5, B.) The loading machine discharges the coal into the hopper with little or no spillage along the sides of the conveyor. The hopper, which is mounted on skids, is moved forward as the face advances. The coal passes from the conveyor to cars on the entry. This method of loading permits coal to be fed uniformly onto the conveyor.

The following crew performs all the labor in this section:

1 loading-machine operator
1 loading-machine helper
1 cutting-machine operator
1 cutting-machine helpar.
1 timberman and faceman
2 pan men
1 driller and shotfirer
1 laborer
1 car trimmer
1 motorman
11

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The average labor required to move the equipment from one set of rooms to a new location and erect it is as follows:

	Man-shifts
To prepare loading station (brush roof, move and erect power units), for 2 units	12
To remove conveyors and timbers, if possible, from two worked-out rooms	3
Total	15

The shaft bottom is 250 feet long and is double-track. Each track is equipped with a car-moving device consisting of a motor-driven endless rope to which are attached "dogs" or "fingers" that engage the cars. A bottom man operates this mechanism, and cars may be switched to either cage. There is an electrical safety switch at the hoisting signal, which can be operated by the cager if a car does not seat properly on the cage or should an empty car not clear when it is pushed off by a loaded car. If the switch is opened the hoist cannot be operated until the equipment is in proper order. This is an excellent safety device.

The mine is ventilated by a propeller-type fan on the surface. The fan operates blowing and produces 98,000 cubic feet of air per minute at 2.6 inches water gage. The main hoisting shaft is upcast, and the return air is on the haulageways.

Electric power is purchased from a public utility and is delivered to the mine at 6,600 volts, 60-cycle, 3-phase, alternating current. This current is converted to direct current for mine use by two 300-kilowatt and one 150-kilowatt motor-generator sets. Power is conducted to the working sections through two 500,000 circular mils cables and 4-0 trolley wire. The track is constructed with 60-pound rail on wooden ties, and bare 500,000-circular mils copper cable is spiked to the ties along the center of the track and bonded to the rail for the return.

Summary of Performance

	Loading into mine cars		Loading onto conveyors	
Tons	31,441		3,633	
Loading-machine shifts	172		19	
Tons per shift per machine	192.8		191.21	
Men per crew per shift	8.30		12.23	
Tons per man	22.02		15.62	
	Minutes per shift	Percent	Minutes per shift	Percent
Loading, squirming, car change	323.82	77.10	302.37	71.99
Delays at loading machine	12.89	3.07	6.63	1.58
Derailments	16.58	3.94	16.09	3.83
Waiting for cars	17.27	4.12	10.79	2.57
Miscellaneous delays	19.02	4.53	68.17	16.23
Place change	30.42	7.24	15.95	3.80
	420.00	100.00	420.00	100.00

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Classification of labor employed during a 24-hour period:

Classification	Day shift	Night shift	Total
Underground:			
Loading-machine section crews loading into cars	72	15	87
Loading-machine section crews loading onto conveyors	11	--	11
Total men on mechanized units	83	15	98
Other underground:			
Cagers	2	1	3
Couplers	2	--	2
Main-line motormen	2	--	2
Relay locomotive crews	7	2	9
Dispatcher	1	--	1
Flagman	1	--	1
Main-line tracklayers	2	--	2
Timbermen	2	1	3
Brushers	--	2	2
Powderman	--	1	1
Laborers	4	2	6
Mason	1	--	1
Pumpers	--	2	2
Electricians	1	1	2
Electrician helpers	3	2	5
Machine repairmen	3	--	3
Mine foreman	1	--	1
Assistant mine foreman	3	1	4
Total other underground	35	15	50
Total underground			148
Surface:			
Hoisting engineers	1	1	2
Generator men	2	--	2
Tipplemen	6	--	6
Weighman	1	--	1
Car droppers	3	--	3
Car trimmers	1	--	1
Electrician	1	--	1
Master mechanic	1	--	1
Machinists	4	--	4
Carpenters and car repairmen	4	--	4
Blacksmith and helpers	3	2	5
Miscellaneous labor	8	2	10
Mine engineer	1	--	1
Office and store	4	--	4
Surface foreman	1	--	1
Superintendent	1	--	1
Total surface	42	5	47
Total surface and underground			195

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Summary for Average Working Day

Mechanization of mine, percent	100
Average daily production, raw coal, tons	1,836
Number of loading machines	10
Number of loading-machine shifts per day	10
Average number of men per unit per shift	9.8
Man-shifts per day on mechanized units	98
Average tons per man per day on mechanized units	18.73
Total employees underground	148
Average tons per day per man underground	12.40
Total employees, surface and underground	195
Average tons per day per man employed	9.42

Mine 31

The coal bed at this mine is opened by a single-track slope 1,600 feet long. The maximum grade on the slope is 21 percent. The bed averages 5 feet 7 inches in thickness and is overlain by 4 inches of shale, which breaks down with the coal. Immediately above the 4-inch shale band is a sandy shale, which ranges in thickness from 6 inches to more than 12 inches. The stratum above this is a sandstone. The bottom is hard, sandy shale.

The mine is 100 percent mechanized, and at the time the mine was visited it produced an average of 860 tons of raw coal per day of five loading-machine shifts. During the winter season production is increased by working eight loading-machine shifts per day. The coal is loaded into mine cars by crawler-mounted mobile loading machines.

Mining Method

The room-and-pillar method of mining is used. The mine is developed by main entries comprising two or three headings. Room entries are turned in pairs on approximately 700-foot centers both right and left off the main entries. Main and room entries are driven 12 feet wide on 44-foot centers, and crosscuts are usually driven on 75-foot centers.

Rooms are turned on an angle of 60° or 65°, usually to the right and left from the room entries. The rooms are necked 12 feet wide for 25 feet and then widened to 30 feet and driven 300 to 650 feet deep on 50-foot centers. Pillars are not extracted.

In some sections of the mine a key-room system of extraction is followed. Rooms are driven in groups of five to seven, and the center room is used as the main haulageway of the group. Crosscuts are turned at an angle and located so that track may be laid from the key room to the adjoining rooms.

The cycle of mining is to timber, cut and drill, blast, and load. The following crew performs this work for each loading machine:

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1	loading-machine operator
1	loading-machine helper
1	cutting-machine man (drill and shoot
1	cutting-machine helper after shift)
1	faceman
1	timberman
2	trackmen
1	motorman
1	brakeman
10	

Rooms are normally timbered with four rows of props on 6-foot centers and staggered. The two middle rows are set 3 feet on each side of the track. Where the contact between the shale and sandstone roof is filled with carbonaceous material it is necessary to use crossbars in addition to posts. These sets are usually placed 6 to 8 feet apart. If the roof becomes fragile and cannot be supported between bars, the shale is taken down and gobbed. The coal produced per prop used averages 10.8 tons.

The coal is cut in the bed 2 to 3 inches above the bottom with shortwall machines equipped with 7-foot cutter bars. The bottom coal is taken up during loading. The face is drilled by the cutting crew with a post-mounted, auger-type, electric drill. The holes are charged with black pellet powder, stemmed with coal dust, and fired by fuse while the men are coming off shift. Approximately 3.57 tons of coal is produced for each pound of explosive.

Crawler-mounted, mobile, loading machines having a rated capacity of 2 tons per minute are used to load the coal. Each loading machine is served by a 6-ton, cable-reel, gathering locomotive, and one car is loaded at a time. The gathering trip comprises four to six cars, and the cars are switched at the nearest crosscut. The cars average 3 tons capacity, are constructed with wood, and are the solid-end type equipped with antifriction bearings. Two hundred sixty cars are in service. The cars are brought to the working section from the main-line partings by two 7-ton relay locomotives that serve three loading-machine sections.

Summary of Performance

	Minutes	Percent
Loading	103.50	24.65
Squirming	41.60	9.90
Car change	75.40	17.95
Delays, waiting for cars	68.90	16.32
Delays, miscellaneous	108.10	25.82
Place change	22.50	5.36
	420.00	100.00
Average number cars loaded		57
Average tons raw coal loaded		171

Main-line trips average 50 cars, and these are transported 9,600 feet to the slope bottom by a 35-ton tandem locomotive. Cars are pulled up the

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slope in 10-car trips by a 400-horsepower electric hoist at a rope speed of 1,200 feet per minute. An automatic derail is placed in the slope near the portal as a protection against runaway trips. The cars are dumped on the tipple by a single-car, motor-driven rotary dump.

Power is purchased, and 10.31 kilowatt-hours is used per ton of coal produced.

The following labor is employed in 24 hours:

Classification	Day shift	Night shift	Total
Underground:			
Mechanical loading units	30	20	50
Other:			
Locomotive operators	6	2	8
Rope rider	1	-	1
Timbermen	4	5	9
Trackmen	4	2	6
Laborers	5	5	10
Electricians	3	-	3
Pumper	1	-	1
Bratticeman	1	-	1
Supervision	1	-	1
Total underground	56	34	90
Surface:			
Hoisting	1	-	1
Machinist	5	-	5
Blacksmith	2	-	2
Laborers	4	-	4
Tipple and substation attendants	3	-	3
Box-car loaders	3	-	3
Car dropper	3	-	3
Lump breaker	4	-	4
Pickers	13	-	13
Foreman	1	-	1
Total surface	39	-	39
Total surface and underground	95	34	129

Summary

Mechanization of mine, percent	100
Average daily production, tons, raw coal	860
Number of mechanical units	3
Number of mechanical-unit shifts per day	5
Average number of men per unit per shift	10
Man-shifts per day on mechanized units	50
Average tons per day per man on mechanized units	17.2
Total employees underground chargeable to mechanization	90
Average tons per day per man underground	9.55
Total number of employees, surface and underground	129
Average tons per day per man employed	6.66

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Mine 32

The main opening of this mine is a slope in the coal bed that outcrops on the surface. The dip of the bed ranges from a maximum of 11 percent at the surface to 1-1/2 percent at the bottom of the slope, approximately 3,900 feet from the portal. The coal bed ranges from 5 feet 6 inches to 5 feet 9 inches in thickness. The overlying strata are 4 inches of bone coal, which usually falls with the coal, sandy shale, and sandstone. At some places in the mine a stratum of draw slate occurs above the bone coal. The bottom is fireclay.

Mining Method

The room-and-pillar system of mining is used. Entries are driven 14 feet wide on 35-foot centers, and these are turned in pairs off the slope along the strike of the bed at approximately 300-foot intervals. Rooms are turned from the haulageway at an angle of 55° and driven 25 feet wide and 300 to 350 feet long on 45-foot centers. A key-room system, comprising three rooms, is generally used, and crosscuts are staggered on 80-foot centers. These crosscuts are angled toward the center or key room. After the rooms on each side of the key room have been driven to the first crosscut, 50 feet and 90 feet inby, respectively, the track in these two rooms is removed and hauling is done through the crosscuts to the track in the key room. Track-maintenance and car-change distance is reduced by this method. Pillars were not being extracted at the time the mine was visited.

The track is in the center of the room, and the working place is timbered with props set on each side of the track on 4- to 6-foot centers. A 3- by 5- by 15-inch cap is used on each prop, and an average of 10 tons of coal is produced per prop. In parts of the mine where draw slate occurs it is necessary to support the roof with crossbars.

The output of the mine averages 925 tons of raw coal per day, and the coal is loaded by five crawler-mounted mobile loading machines (four of these machines work on the day shift and one at night), one track-mounted loading machine, and three pit-car loaders. A track-mounted combination cutting and shearing machine equipped with a 9-foot cutter bar and a track-mounted undercutting machine equipped with a 7-1/2-foot bar are used to cut the coal for the crawler-mounted mobile loading machines. A shortwall cutting machine equipped with an 8-foot bar is used to cut the coal in the section where the coal is loaded by pit-car loaders and the track-mounted mobile loading machine. All places are cut in the bed about 4 inches above the bottom. Where the face is sheared in addition to the undercut, the shear cut is made in line with the right rail of the track. The coal is drilled with a portable, electric, auger-type drill, and usually four holes are drilled in the face. The collar of the holes is placed approximately 2 feet below the bone coal, and the holes are pointed upward. Where a shear is not made the two center holes are pointed toward each other. The holes are charged with black pellet powder and fired after shift when the men have left the mine.

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The following crews are assigned to each of the various types of loading equipment:

Crawler-mounted mobile loading machine:
- 1 loading-machine operator
- 1 loading-machine helper
- 1 faceman
- 1 rockman
- 1 motorman
- 1 brakeman
- 1 trackman
- 1 trackman helper
- 2 cutting-machine men, who also drill and prepare the places for two loading machines
- 2 trackmen, who are assigned to two loading machines

Track-mounted mobile loading machine:
- 3 loading-machine men
- 1 trackman and timberman
- 1 gathering driver
- 1 relay driver

Pit-car loader:
- 2 loaders
- 1/3 mule driver
- 1/3 tracklayer and timberman

Each crawler-mounted mobile loading machine is served by a cable-reel gathering locomotive. Cars are brought from the slope parting to the nearest key room by a main-line trolley locomotive. One car is loaded at a time, and the cars are switched at the nearest crosscut. Cars are the end-dump type, and each car transports an average of 2.9 tons of mechanically loaded coal.

An average summary of performance in crawler-mounted mobile loading-machine sections is as follows:

	Minutes	Percent
Loading	82.62	19.70
Squirming	33.15	7.90
Car change	82.25	19.60
Transportation delays	140.76	33.50
Miscellaneous delays	81.22	19.30
	420.00	100.00
Average cars loaded per shift per machine		51
Average tons raw coal loaded per shift per machine		148

Both the track-mounted mobile loading machine and pit-car loading section are serviced by mules. In the loading-machine section one mule services the loading machine and another mule transports one-car trips from the section to the slope parting, a distance of 1,250 feet at the time the mine was visited. A mule is used to service three pit-car loaders. A main-line locomotive transports the trips to and from the slope parting and section sidetracks.

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The cars are transported up the slope to the tipple in trips of 10 by a 350-horsepower electric hoist. The cars pass over a crossover dump and are dumped singly on the tipple.

The mine is ventilated by a 5-foot centrifugal fan driven by a 20-horsepower electric motor and operated blowing. The ventilating circuit is continuous, and the slope is the return air course.

All power is purchased and is brought into the mine over an armored cable in a borehole. The alternating current is 2,600 volts, 60-cycle, 3-phase and is transformed by three 50-kv.-a. transformers to 440-volts, 60-cycle, 3-phase alternating current for use on all mining equipment, including loading and cutting machines, drills, and pumps, except haulage equipment, which is operated by direct current. Portable electric drills are equipped with a fourth wire, which is grounded for safety. Direct current for electric haulage is generated by a 125-kilowatt motor-generator set. The alternating current at the converting station in the mine is transformed from 2,600 volts to 440 by two 75-kv.-a. transformers. Alternating current is supplied to the electric motor on the motor-generator set at 440 volts, and direct current is generated at 275 volts.

Classification of labor employed during a 24-hour period follows:

Classification	Day shift	Night shift	Total
Underground:			
Loading-machine crews:			
4 machines	36	-	36
1 machine	-	8	8
1 machine	6	-	6
Cutting-machine crews:			
3 machines	2	4	6
1/2 machine	-	2/1	1
Total employees on mobile loading machines	44	13	57
Pit-car loaders, 3 1/	6	-	6
Cutting-machine men	-	2/1	1
Trackmen	1	-	1
Driver	1	-	1
Total employees on pit-car loaders	8	1	9
Total employees chargeable to mobile loading machines and pit-car loaders			66
Other underground:			
Rope rider	1	-	1
Main-line locomotive crews	4	-	4
Main-line track-laying crews	4	2	6

1/ Pit-car loaders considered as hand-loading onto conveyors.
2/ One crew cuts for pit-car loaders and track-mounted mobile loading machine.

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Classification	Day shift	Night shift	Total
Other underground (Cont'd.):			
Ventilation	1	1	2
Pumpman	-	1	1
Slopeman	-	1	1
Electricians	1	1	2
Machine repairman	1	-	1
Shotfirer	-	1	1
Supervision	2	-	2
Total other underground	14	7	21
Total underground			87
Surface, including tipple			40
Total, underground and surface			127

Summary for Average Working Day

Mechanization of mine, percent		100
Average daily production, raw coal, tons		925
Mobile loading machine, tons	742	
Track-mounted loading machines, tons	95	
Pit-car loaders	88	
Number of mobile loading machines		5
Number of mobile loading machine-shifts per day		6
Average number of men per unit per shift		9.5
Man-shifts per day on mobile loading machines		57
Average tons per man per day on mobile loading machines		14.7
Number of pit-car loaders		3
Number of pit-car loader-shifts per day		3
Average number of men per unit per shift		3
Man-shifts per day on pit-car loaders		9
Average tons per man per day on pit-car loaders		9.8
Man-shifts per day on mobile and pit-car loaders		66
Average tons per man per day on mechanized units		14.0
Total employees underground		87
Average tons per day per man, underground		10.6
Total employees, underground and surface		127
Average tons per day per man employed		7.3

Mine 33

This mine, which is an example of continuous flow of coal from face to tipple, is extracting coal from a bed averaging 40 inches in thickness. The bed contains a 4-inch shale parting 24 inches above the floor. The dip of the bed is 2-1/2 percent northeast.

The stratum above the coal is draw slate averaging 18 inches in thickness, and this is overlain by a hard, sandy shale, which is the main roof. The bottom is a hard shale containing occasional rolls.

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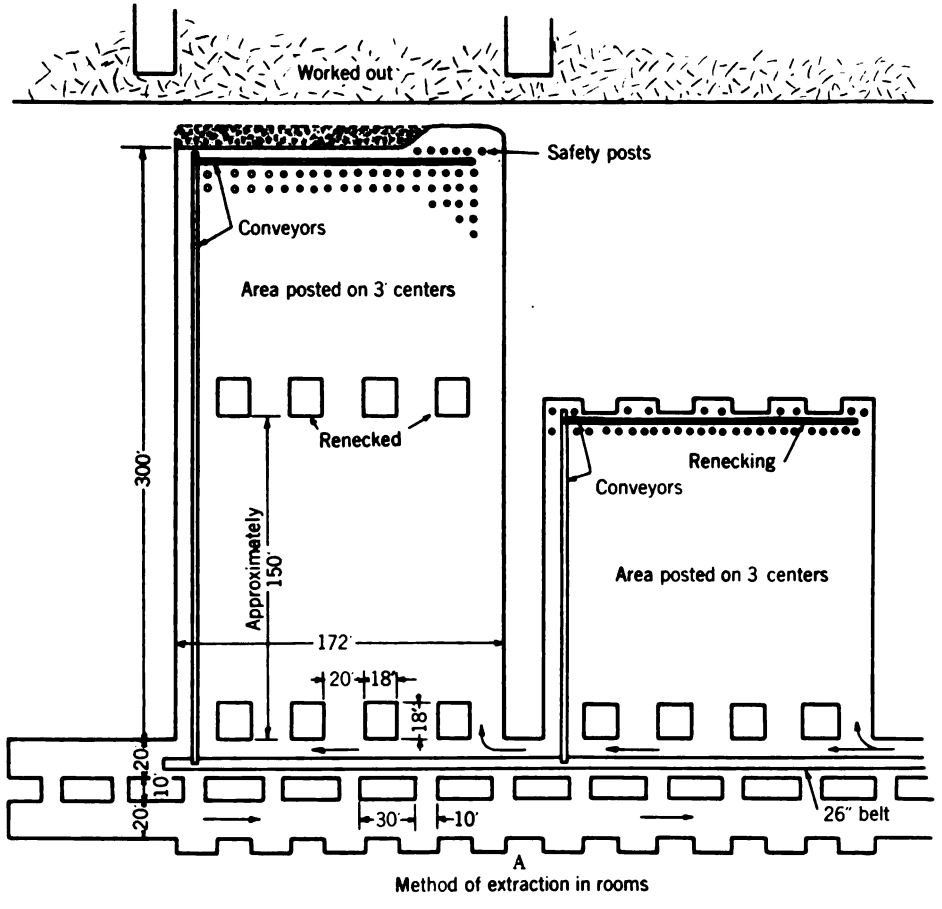

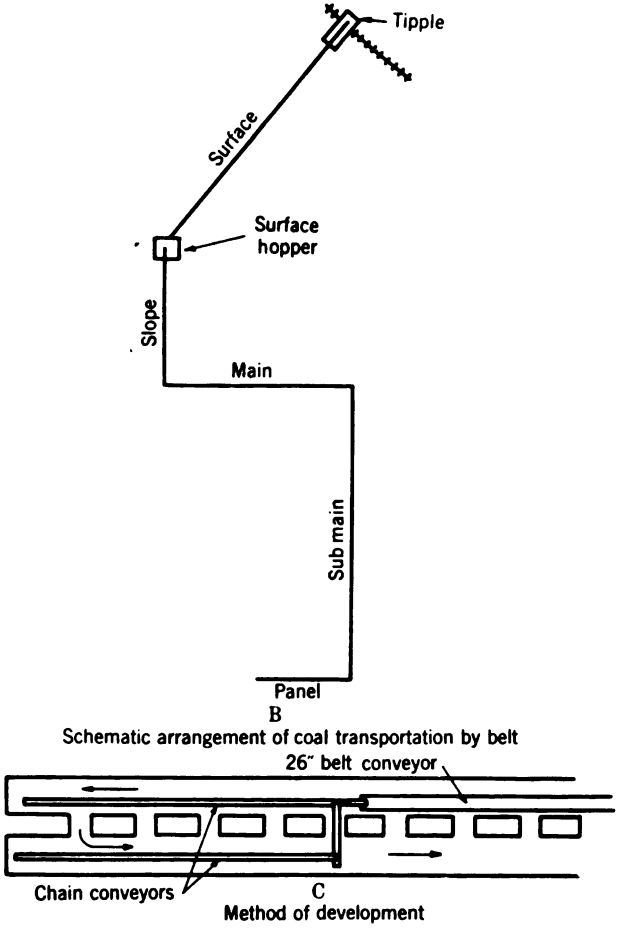

Figure 6.—Mining method in use at mine 33.

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Operation of the mine is seasonal and production averages 1,000 tons in two shifts per day. The mine has two openings - the haulageway, which is a 16° slope 450 feet long (equipped with a belt conveyor), and a fan shaft, which is the return of the ventilation system. The slope is equipped with track for transporting supplies into the mine. Supplies are transported in cars in the main entries over track laid adjacent to the conveyor belt. A rubber-tired buggy is used to haul supplies to the faces.

Mining Method

A room-and-pillar panel system of mining is used. Wide rooms that average 300 feet in length are driven from both entries of a pair of panel headings. The entries are driven 20 feet wide on 30- to 35-foot centers and are approximately 1,000 feet long between main entries. Belt conveyors are installed on main entries, and the draw slate in these entries is taken down.

Rooms range in width from 165 to 172 feet and are developed by driving five openings or necks 20 feet wide on 38-foot centers for a distance of 18 feet. Crosscuts are then driven to connect these necks, and the inby rib of the crosscut becomes the face of the room. When the face has been advanced 150 feet the room is renecked, and this practice leaves four 18-foot blocks similar to those along the entry. This second set of pillars is left as a precaution against squeezes. The roof of the open area is supported by wooden posts set on 3-foot centers. (See fig. 6, A.)

All coal is hand-loaded onto chain-type conveyors. While rooms are being necked, rubber-tired portable conveyors are used to transport the coal to a conveyor belt in the haulageway. After the necks have been connected and the face formed, a conveyor approximately 145 feet long is installed along the face. The coal is discharged from this conveyor onto a room conveyor, which transports the coal to the main belt conveyor. The face conveyor is moved ahead as the face advances. The main belt, approximately 5,000 feet long, comprises five units - panel, 500 feet; submain, 1,500 feet; main, 1,000 feet; slope, 460 feet; and surface, 1,500 feet. (Refer to fig. 6, B.)

Two chain conveyors and one transfer conveyor are used in entry-development work. (Refer to fig. 6, C.) The entries are usually advanced 200 feet with the chain conveyors, and then these conveyors are dismantled and the belt conveyor is extended.

All cutting is done in the middle band by means of a combination longwall and shortwall mining machine equipped with a 6-foot cutter bar.

The coal is drilled with a portable electric drill using "mole-foot" bits. The holes in room work are 8 to 10 feet apart in the lower bench and about 10 feet apart in the upper bench. In narrow work and development three holes are placed in the upper bench and four in the lower. All holes are charged with black blasting powder and fired by fuse after the men have left the mine.

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The equipment for each room comprises a mining machine and an electric drill in addition to each conveyor.

Four rooms are worked during the production season, and two cuts per day are usually obtained in each room. The following men are assigned to each room unit:

1	face boss
2	machinemen
1	supplyman
15	coal loaders
2	drillers and muckers
21	

The labor employed in a 24-hour period is as follows:

Classification	First shift	Second shift	Third shift	Total
Underground:				
Loaders on walls	60	16	-	76
Room supply men	4	-	-	4
Machinemen	8	-	8	16
Development (cut and load)	5	5	-	10
Face bosses	4	-	-	4
Total men on mechanized units	81	21	8	110
Other underground:				
Rope man (supply hoist)	1	-	-	1
Beltmen	3	3	3	9
Electricians	2	1	1	4
General Supplies	2	-	-	2
Rockmen	-	-	4	4
Supervision	2	1	1	4
Total other underground	10	5	9	24
Total underground	91	26	17	134
Surface:				
Mine bin	5	2	-	7
Tipple and surface plant	18	-	-	18
Total surface	23	2	-	25
Total employees				159

Coal produced on the second shift comes from development and that portion of the walls not loaded by the first shift. The third shift prepares the walls for the first shift.

Summary

Mechanization of mine, percent	100
Average daily production from mechanized units, tons raw coal	1,000
Number of conveyor units	6
Number of conveyor units per shift per day, development	4

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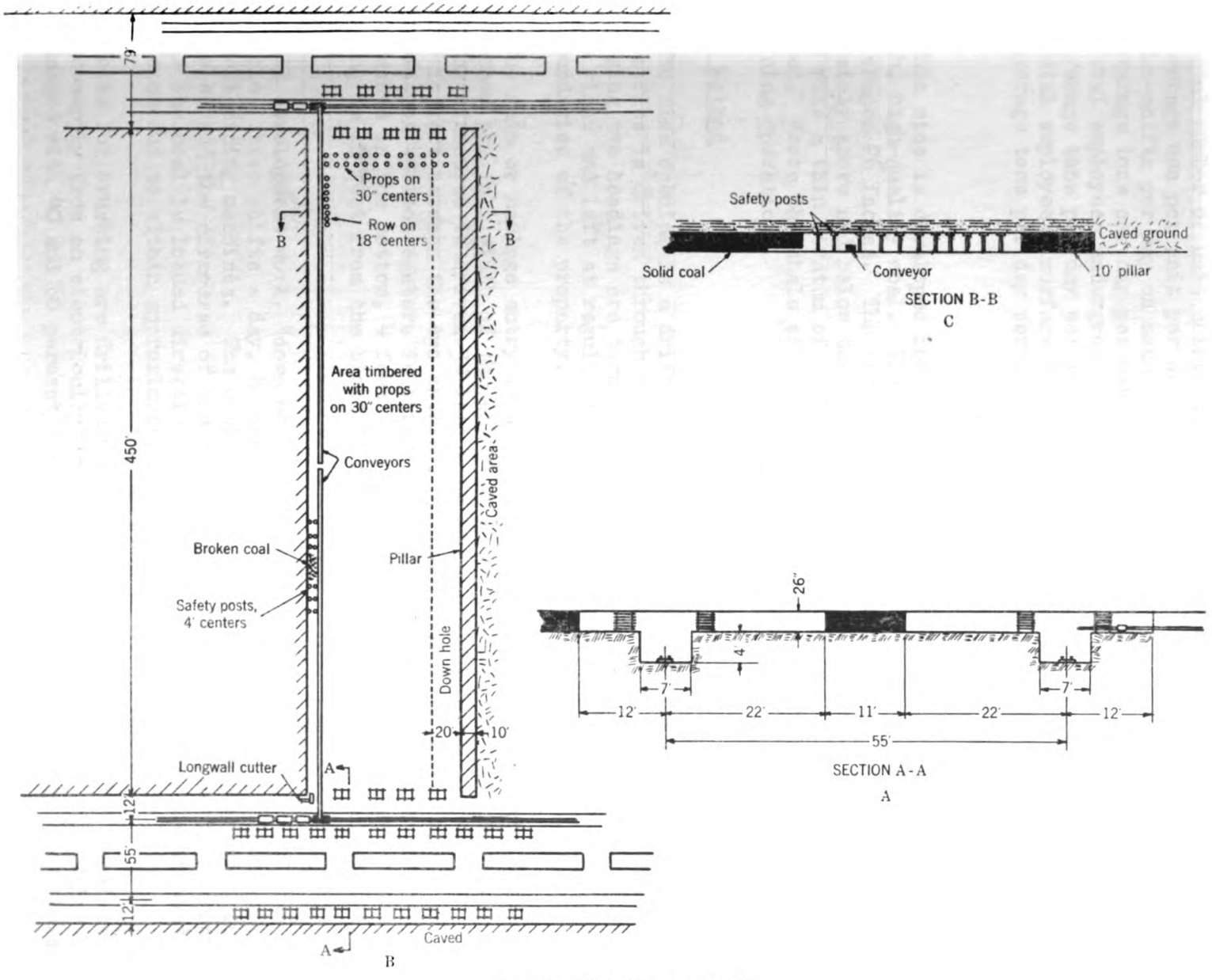

Figure 7.—Mining system at mine 34.

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Summary (Cont'd.)

Number of conveyor units per shift per day, walls	5
Total number of unit shifts per day	9
Average men per unit per shift	12.2
Man-shifts per day on mechanized units	110
Average tons per day per man on mechanized units	9.10
Total employees underground	134
Average tons per day per man underground	7.46
Total employees, surface and underground	159
Average tons per day per man employed	6.30

Mine 34

This mine is developed for a long-face system of mining in a thin bed of low-ash, high-quality coal. The bed ranges in thickness from 6 to 30 inches and averages 26 inches. The bed is clean and free from partings. The strata immediately above and below the coal are hard, sandy shales. In some areas of the mine a thin stratum of shale, commonly called draw slate, overlies the coal bed. Where the shale attains a thickness of 3 inches it is removed during mining operations.

Mining Method

The mine opening is a drift in the outcrop of the coal bed. A pair of main entries is driven through the center of the property. Cross entries comprising two headings are turned at right angles to the main entries, both to the right and left at regular intervals. The cross entries are driven to the boundaries of the property.

The main or haulage entry is driven 10 to 12 feet wide, and the bottom is brushed the full width of the entry to a depth of 4 feet. The parallel entry or aircourse is driven 34 feet wide and is not brushed; a 15-foot pillar is left between the two entries. A pair of cross entries driven 34 feet wide on 45-foot centers is turned about every 530 feet. Both entries are brushed in the bottom, 4 feet deep and 7 feet wide. The center of the brushing is 12 feet from the block of coal to be extracted. (Refer to fig. 7, A.)

All development work, "down holes" and entries, is done on a continuous cycle, three shifts a day, 6 days a week. Cutting is done by means of shortwall mining machines. The coal is hand-loaded onto chain conveyors in down holes and the aircourse of the main entry. In the development of cross entries the coal is loaded directly into mine cars, as the entry is brushed after each cut to within approximately 5 feet of the face.

Holes for brushing are drilled with a jackhammer drill, which receives its air supply from an electrically driven mine-car compressor. The holes are charged with 40 and 60 percent dynamite and fired by fuse and detonators.

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The panel of coal between pairs of cross entries averages 450 feet in width. The extraction of this block is begun by driving a cross room or "down hole" 20 feet wide across the block of coal. This down hole is started 20 feet inby the main entry and driven from both sides of the block. After the down hole has been completed, the inby rib becomes the initial face of the wall. The wall is advanced toward a predetermined boundary in the following sequence: (1) Cutting, (2) drilling and shooting, (3) moving up conveyors and timbering, and (4) loading and setting safety timber.

Cutting

The cut is made in the bottom of the bed by a longwall mining machine equipped with a 6-foot cutter bar. The cutting crew consists of two men who work on the second shift.

Drilling and Shooting

A crew of three men also employed on the second shift drill the faces of two walls with a portable, electric, auger-type drill. The holes are spaced on 8- to 10-foot centers in the center of the bed and are charged with one-half stick of pellet blasting powder and fired by fuse.

Moving Conveyor and Timbering

After the face has been prepared, a crew of four men on the third shift moves the conveyors of two walls to within 3 feet of the face and places permanent posts back of the conveyors. The posts are set on 30-inch centers except that the row immediately adjacent and outby the conveyor, which is set on 18-inch centers or closer, as conditions require.

Loading

At the time the mine was visited the coal was hand-loaded onto chain conveyors by a crew of 18 men working on two walls. During the loading operation the loaders set temporary safety posts on 4-foot centers between the conveyor and the face.

Each wall is equipped with two chain conveyors, each approximately 235 feet long. The tail pieces are placed within a foot or two of each other, and the coal moves in opposite directions, discharging into cars on the cross entires. (Refer to fig. 7, B.) An average cut produces 80 to 90 cars, each having a capacity of 1.5 tons. Successive cuts are loaded from the wall, and the face is advanced until the posts in the mined-out area indicate that the weight of the overburden is becoming excessive. It is usually possible to advance the wall 20 to 25 cuts before the face must be abandoned. When this occurs a 10-foot pillar is left, and a new down hole is developed for another wall.

While cutting operations are in progress two men erect a double rock-filled crib, 6 by 6 feet, on each side of the haulageway. The crib is built of 4- by 6-inch by 6-foot softwood, and the double crib is capped by 4-

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by 6-inch by 12-foot timbers. These cribs are built 14 inches from the edge of the brushing. Where necessary, the roof of the haulageway is timbered with 6- by 8-inch by 12-foot timbers set on the cribs.

Haulage

The track is 42-inch gage and is constructed with 40-pound rail in main entries and 30- to 35-pound rail in cross entries. All track is laid on 4- by 10-inch by 6-foot hewed oak ties ballasted with mine refuse. Steel ties are used in advancing headings.

Four electric trolley locomotives (three 6-ton and one 4-ton) transport the coal 2-1/2 miles from the working places to the tipple. A trip usually consists of 16 cars. The mine is equipped with 144 steel drop-bottom cars. Eight cars are usually assigned to each conveyor or side of a wall. At the walls the cars pass by gravity under the loading head of the conveyor, and approximately 415 tons of raw coal is transported per day.

Ventilation

The mine is ventilated by a centrifugal fan driven by a 30-horsepower, 2,300-volt, alternating-current motor. The fan operates exhausting and circulates 40,000 cubic feet of air per minute. Permanent stoppings are constructed of rock, and these are plastered with a mixture of clay and cement.

Preparation

The coal is sized; the plus-3-inch is cleaned by hand-picking and the minus-3-inch is cleaned in the working.

Mine employees chargeable to mechanized production for a 24-hour period are listed in the following table. Where employees handle coal from both hand-loading and mechanized sections, the number charged to mechanized production is prorated according to the ratio of the mechanized production to the total output of the mine. Eighty-one and eight-tenths percent of the production is mechanically loaded.

Classification	First shift	Second shift	Third shift	Total
Walls:				
Loaders, 1 wall	10	--	--	10
Loaders, 1 wall	8	--	--	8
Timbermen	4	--	--	4
Car trimmer	4	--	--	4
Machinemen and scrapers	--	4	--	4
Cribmen	--	4	--	4
Drillers	--	2	--	2
Shotfirers	--	1	--	1
Push-up men	--	--	4	4
Total	26	11	4	41

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Classification	First shift	Second shift	Third shift	Total
Development - 4 down holes and 1 entry:				
Machinemen (also loaders)	10	10	4	24
Car trimmers	5	5	2	12
Total	15	15	6	36
Underground employees chargeable to mechanized units				77
Other underground:				
Motormen and brakemen	8	2	1	11
Trackmen, wiremen, and bonders	2	2	-	4
Timbermen, bratticemen, and pumpers	3	1	1	5
Electricians	2	-	-	2
Supervision	3	1	1	5
Total other underground	18	6	3	27
Other underground chargeable to mechanized production				22
Total underground chargeable to mechanized production				99
Surface:				
Shopmen and mechanics	3	-	-	3
Sand-dryer	1	-	-	1
Tipplemen	8	-	-	8
Weighmen and foremen	1	-	-	1
Total	13	-	-	13
Total surface employees chargeable to mechanized production				11
Total employees chargeable to mechanized production				110

Summary

Mechanization of mine, percent	81.8
Average daily production from mechanized units, raw coal, tons	338
Average daily production from mechanized units, walls, raw coal, tons	232
Average daily production from mechanized units, development, raw coal tons	106
Number of conveyor units, walls	1/2
Number of conveyor units, development	5
Average conveyor shifts per day, walls	2
Average conveyor shifts per day, development	12
Total conveyor shifts per day	14
Man-shifts per day on mechanized units, walls	41
Man-shifts per day on mechanized units, development	36
Total man-shifts per day on mechanized units	77
Average men per unit per shift, walls	20.5
Average men per unit per shift, development	3.0
Average men per unit per shift, walls and development	5.5
Average tons per man per shift, walls	5.67

1/ A wall is considered a unit, although two conveyors are used to transport the coal.

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Summary (Cont'd.)

Average tons per man per shift, development	2.94
Average tons per man per shift, walls and development	4.39
Total employees underground chargeable to mechanized production	99
Average tons per man per shift underground	3.42
Total employees, surface and underground, chargeable to mechanized production	110
Average tons per man per shift, all employees	3.08

GENERAL DISCUSSION

Mining operations were conducted on more than one shift in all the mines described. There are advantages to loading coal mechanically on more than one shift, but proper precautions should be taken to preserve the safety of operations.

The investment required to equip a mine for mechanical mining is great, and where the daily output can be produced over two or more shifts by the same equipment a smaller capital charge per ton will result.

Rapid extraction from a given area due to multiple shifting should result in greater recovery, that is, in conservation of coal resources. Roof conditions are likely to cause less trouble when extraction is accelerated, as the coal is removed before the full effects of roof action are operative. The rapid development of fresh faces of the coal bed, however, increases the hazard due to accumulation of dust and the increased bleeding of inflammable gas into the working places. Mines considered nongaseous under hand-loading methods because of slow advance of the working faces may produce gas in dangerous quantities under the rapid advance of mechanized operations. This hazard should be recognized and proper precautions taken to safeguard the men. It is important that the same amount of supervision should be given on all shifts. All working places should be adequately rock-dusted.

At four of the mines described, where the coal is loaded by mobile loading machines, water is used on the cutter bar of mining machines to lay the dust, and usually sprinkling is practiced during loading.

Systematic timbering is done in all mines, and the coal is broken by permissible explosives in all working places of two mines and in one section of another where shots are fired on shift. At one mine Cardox is used to break down the coal.

Black pellet powder is used for breaking down the coal at some mines, but this is done by shotfirers after the men have left the mine, except at one operation where the shots are fired as the men are leaving the mine. The use of black powder in coal mines when men are in the mine is discussed in Bureau of Mines Safety Board Decisions 2 and 12.5/

5/ Recommendations of the United States Bureau of Mines on Certain Questions of Safety as of October 1, 1936: Bureau of Mines Inf. Circ. 6946, June 1937, pp. 6-7 and 19-22.

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At one mine an automatic derail is used at the top of the slope as a safeguard against runaway trips.

A commendable safety device is an electrical safety switch placed at the hoisting signal of a shaft mine. If a car does not seat properly on the cage, or if an empty car does not clear when pushed off by a loaded car the safety switch is opened by the cager, and the hoist cannot be operated until the equipment is in proper condition.

Hand-held, alternating-current, electric auger drills used for drilling the coal face at one mine are grounded by a fourth wire. This grounding of alternating-current machines is commendable and should be generally practiced.

Worked-out panels are permanently sealed at one mine. This practice obviates the necessity of ventilating large, worked-out areas and simplifies the ventilating system.

EXPLANATION OF GRAPHS

Table 1 summarizes performance at the mines where mobile loading machines are used.

The data in Progress Reports 1 and 2 and in the present report were used in preparing the graphs. The curves are interesting and show trends that may be verified by further investigation.

Figure 8 is a curve showing the weighted average of the operating performance at 28 mines and indicates the rapid rate at which the tonnage output per loading machine per shift increases with increased thickness of the coal bed. The limiting points of this variation have not been determined.

Points 9 feet-197 tons and 9 feet-682 tons are in the same mine. The lower point represents the performance of loading machines with a rated capacity of 2 tons per minute. These machines are working in entries 14 feet wide, and the coal is loaded into cars that have a capacity of 2.86 tons The delays average 16 percent of the total working time. The higher point, which is near the weighted-average curve for a bed 9 feet thick, represents the performance of loading machines with a rated capacity of 4 tons per minute. The coal is loaded from rooms 24 feet wide into shuttle cars of 7.12 tons capacity. The average delays are 9 percent of the total working time. The influence of size of cars, capacity of machines, and width of working places is shown by this example.

Points 10 feet-380 tons and 12 feet-360 tons represent the performance of loading machines that have a rated capacity of 3.5 tons and 3.0 tons per minute, respectively. The machines are operating under adverse physical conditions of excessive grades, and production of both mines is below the average. These grades result in slower trammining and longer time for car change, and other transportation problems. The influence of physical conditions on operating performance is illustrated.

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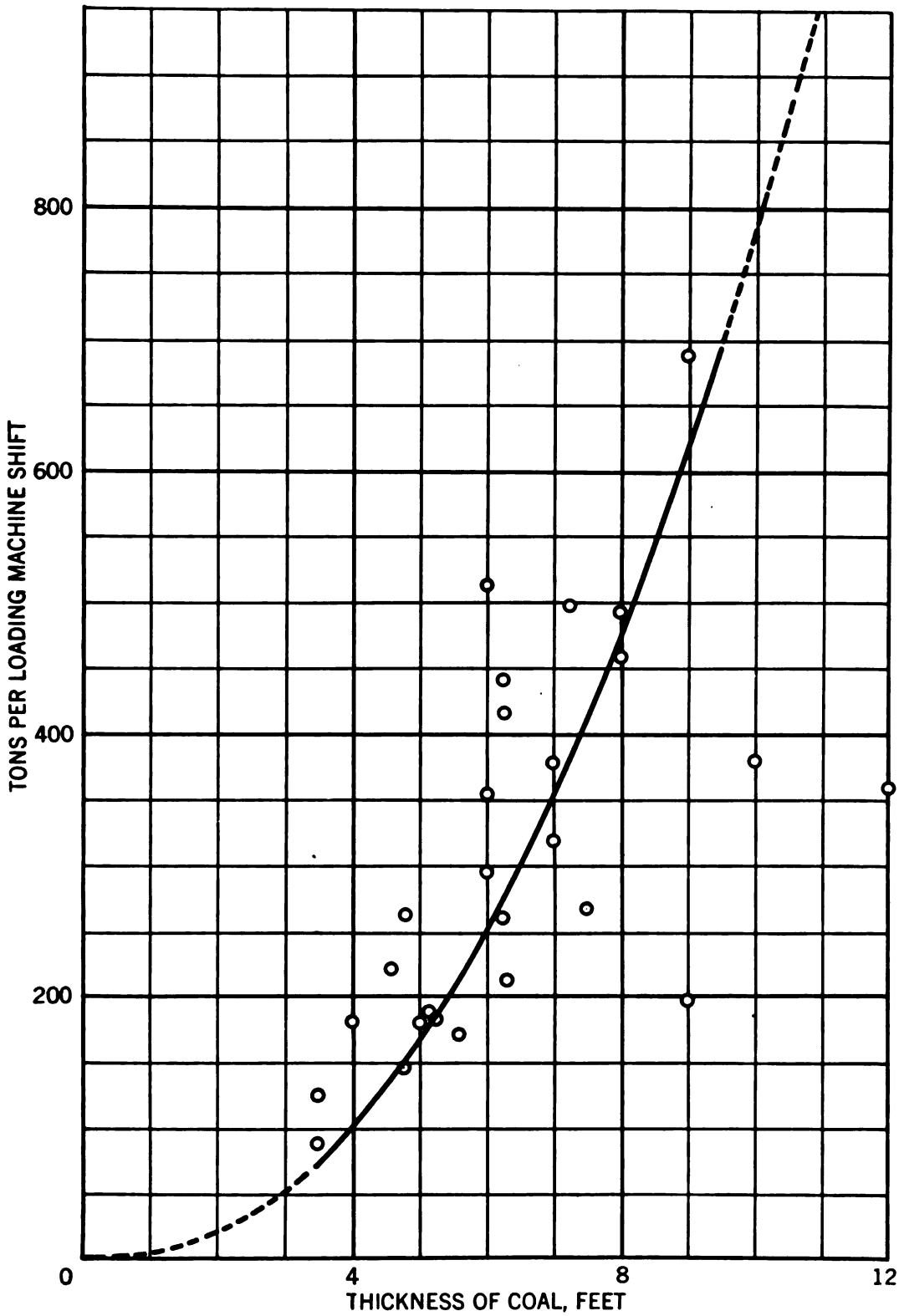

Figure 8.—Relation of thickness of coal to tons per loading-machine shift.

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TABLE 1.- Summary of performance, mobile loaders

	Mine		
	26	27	28
Description of mechanization:			
a. Cutting machines, type	Shortwall	Shortwall	Shortwall
b. Loading machines, type	Crawler-mounted	Crawler-mounted	Crawler-mounted
c. Machine loading	Chain conveyors	Conveyors and mine cars	Shuttle cars and mine cars
Location of mine	Alabama	Alabama	Wyoming
Percent of mine mechanized	100	50	100
Average daily production from mechanized units, tons	475	755	4,880
Thickness and dip of coal bed	50 inches - rolling	62 inches - rolling	18 to 28 ft.2/ 3-1/2 percent
Number and hours of shift in mine	2 - 7-hour	See text.	2 - 7-hour
Number and hours of shift in tipple	1 - 7-hour	1 - 7-hour	2 - 7-hour
Number of loading machines	1	3	5
Number of loading-machine shifts per day	2	4	10
			Large / Small
Average production per loading machine per shift	238	189	682 / 197
Average number of men per unit per shift	11	13.25	18 / 8
Man-shifts per day on mechanized units	22	53	108 / 32
Average tons per man per day on mechanized units	21.6	14.2	37.9 / 24.8
Total number of employees underground	36	75	194
Average tons per day per man underground	13.2	10.1	25.1
Total number of employees, surface and underground	51	87	256
Average tons per day per man employed	9.3	8.7	19.1
Average tons of coal produced per pound of explosive	7.72	3.88	3/1.68
Average tons of coal produced per prop	10.9	3.0	1/
Total power consumed per ton of coal, kw-hr.	1/	1/	4.8
Size of mine car, tons	Gathering conveyors to 0.75 to 1.2	2.0	7.12-ton shuttle cars 2.86-ton mine cars

(See page 37 for footnotes.

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TABLE 1.- Summary of performance, mobile loaders (Cont'd.)

	Mine		
	29	30	31
Description of mechanization:			
a. Cutting machines, type	Track-mounted	Shortwall	Shortwall
b. Loading machines, type	Crawler- and track-mounted mobile loaders	Crawler-mounted mobile loaders	Crawler-mounted mobile loaders
c. Machine loading	Mine cars	Mine cars	Mine cars
Location of mine	Montana	Montana	Montana
Percent of mine mechanized	100	100	100
Average daily production from mechanized Units, tons	1,335	1,836	860
Thickness and dip of coal bed	8-1/2 feet 4/ 4-1/2 percent	4-1/2 to 6 ft.	5 feet 7 inches
Number and hours of shift in mine	See text.	See text.	2 - 7-hour
Number and hours of shift in tipple	1 - 7-hour	1 - 7-hour	1 - 7-hour
Number of loading machines	4	10	3
Number of loading-machine shifts per day	5	10	5
Average production per loading machine per shift	267	184	172
Average number of men per unit per shift	8.6	9.8	10
Man-shifts per day on mechanized units	43	98	50
Average tons per man per day on mechanized units	31.0	18.7	17.2
Total number of employees underground	90	148	90
Average tons per day per man underground	14.8	12.4	9.5
Total number of employees, surface and underground	127	195	129
Average tons per day per man employed	10.5	9.4	6.7
Average tons of coal produced per pound of explosive	2.85	1/	3.57
Average tons of coal produced per prop	8.5	7.4	10.8
Total power consumed per ton of coal, kw-hr.	8.54	7.04	10.31
Size of mine car, tons	3.5	2.1	3.0

(See page 37 for footnotes).

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TABLE 1.- Summary of performance, mobile loaders (Cont'd.)

	Mine 32		
Description of mechanization:			
a. Cutting machines, type	Track-mounted & shortwall		
b. Loading machines, type	Crawler- and track-mounted mobile loaders and pit-car loaders		
c. Machine loading	Mine cars		
Location of mine	Montana		
Percent of mine mechanized	100		
	Mobile loaders	Pit car loaders	Total
Average daily production from mechanized units, tons	837	88	925
Thickness and dip of coal bed	5 feet 7-1/2 inches		
Number and hours of shift in mine	2 - 7-hour		
Number and hours of shift in tipple	1 - 7-hour		
Number of loading machines	5	3	
Number of loading-machine shifts per day	6	3	
Average production per loading machine per shift	139	29.3	
Average number of men per unit per shift	9.5	3	
Man-shifts per day on mechanized units	57	9	66
Average tons per man per day on mechanized units	14.7	9.8	14.0
Total number of employees underground			87
Average tons per day per man underground			10.6
Total number of employees, surface and underground			127
Average tons per day per man employed			7.3
Average tons of coal produced per pound of explosive			4.03
Average tons of coal produced per prop			9.87
Total power consumed per ton of coal, kw-hr.			4.65
Size of mine car, tons			2.9

1/ Not available.
2/ 9 feet of bed is mined.
3/ Tons per pound of carbon dioxide.
4/ 7-1/2 feet of bed is mined.

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Point 6 feet-514 tons, which is above the weighted average, is at a mine where the coal is loaded into cars having a capacity of 5.8 tons by a loading machine with a rated capacity of 3 tons per minute. The loading time at this mine is a high percentage (58.7) of the total time. A short car-change distance is maintained, which results in quick car changes. An average of 16.6 percent of the time is spent in changing cars. Transportation delays were 14.6 percent of the total time. The high loading rate is the result of planning and coordination of all phases of the mining cycle.

Point 3.5 feet-125 tons, which is also above the average curve, is at a mine where the coal is loaded onto a room conveyor by a loading machine having a rated capacity of 0.75 ton per minute. The flow of coal from working place to tipple is accomplished by conveyors, and only 6.2 percent of the working time is lost because of transportation delays.

Figure 9 is the weighted average curve of the number of men employed per loading unit plotted against the tons produced per loading machine per shift. The men assigned to a loading machine include loading-machine operators, cutting-machine men, drillers, shooters, face men, timbermen, and transportation men. The number of men per machine ranges from 6.5 to 18 at the mines studied. Physical conditions in and surrounding the bed and system of gathering affect the number of men employed per loading unit. Where the roof requires close timbering, additional timbermen and facemen are required so that mining operations can be conducted safely. The duty of these men is to maintain the working place in safe condition and without loss of time to the loading machine.

Point 213 tons-17 men, which is 5.5 men above the average, represents the condition at a mine where a thick middle band is cut, and additional men are required to remove these rock cuttings before the working place is prepared for loading.

Point 355 tons-9 men, which is 5.5 men below the average, represents a mine where the coal is loaded onto conveyors and physical conditions surrounding the bed are such that no regular timbermen are used with the individual loading machines. The use of conveyors obviates gathering-transportation men.

In figure 10, curve A is based upon the weighted average of men charged to mobile loading units. This curve indicates that the number of men chargeable to mechanized units increases with increased daily production, but that the number of men decreases from 54 per 1,000 tons for production up to 1,000 tons per day to 35 per 1,000 tons for production between 4,000 to 5,000 tons per day. The number of men chargeable to mobile loading units at the mines included in this report ranges from 28.6 minimum to a maximum of 70 per 1,000 tons production. The minimum number of men employed per 1,000 tons is at a mine where roof conditions are excellent and the loading time is a high percentage of the total time. The maximum point is at a mine where adverse physical conditions, irregular thickness of the bed, and the presence of a variable middle band have a limiting effect on the loading machine.

Curve B, figure 10, is based upon the weighted average of total employees underground chargeable to mechanized production from mobile loading machines.

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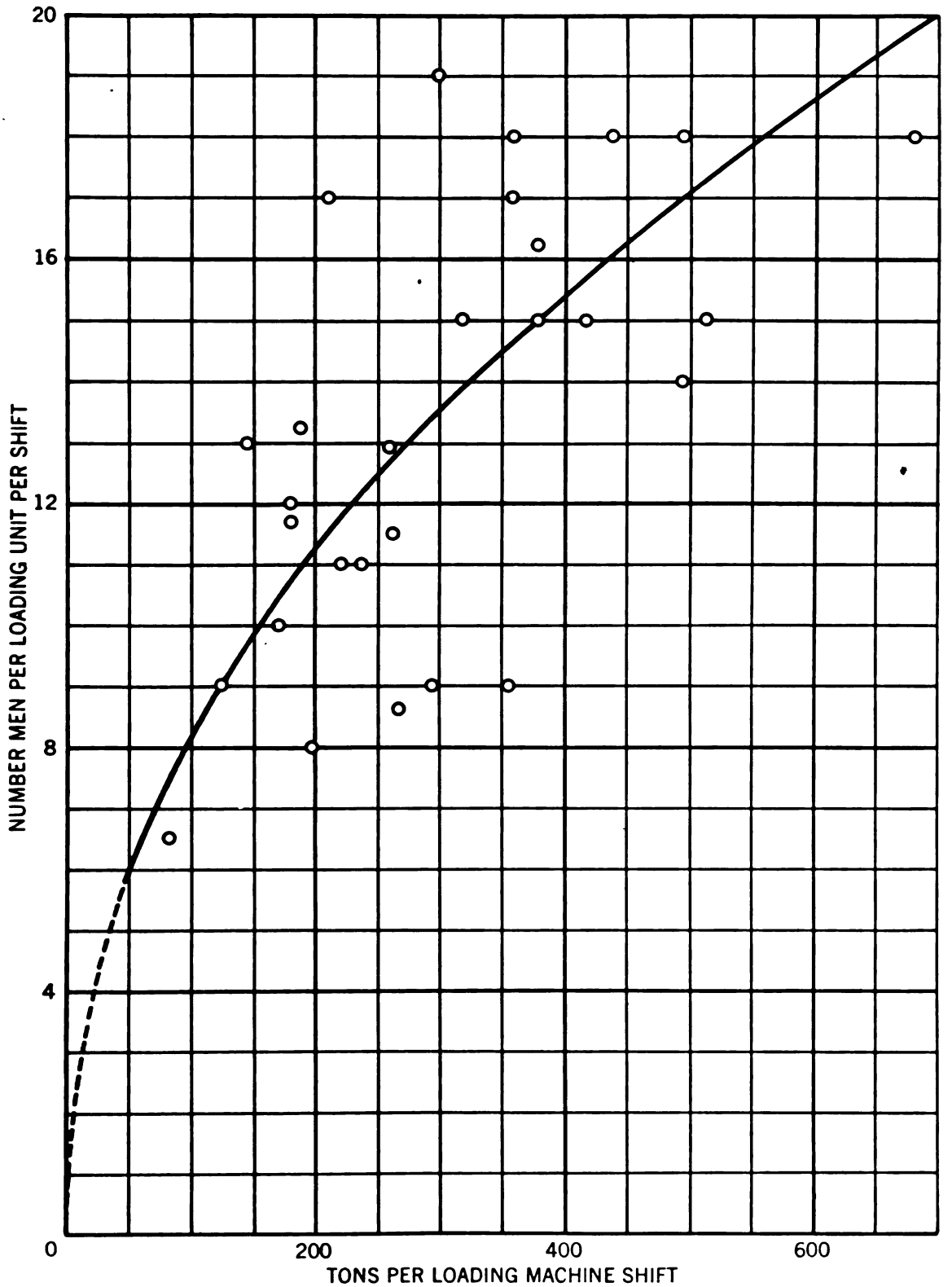

Figure 9.—Number of men per loading unit per shift and tons per loading-machine shift.

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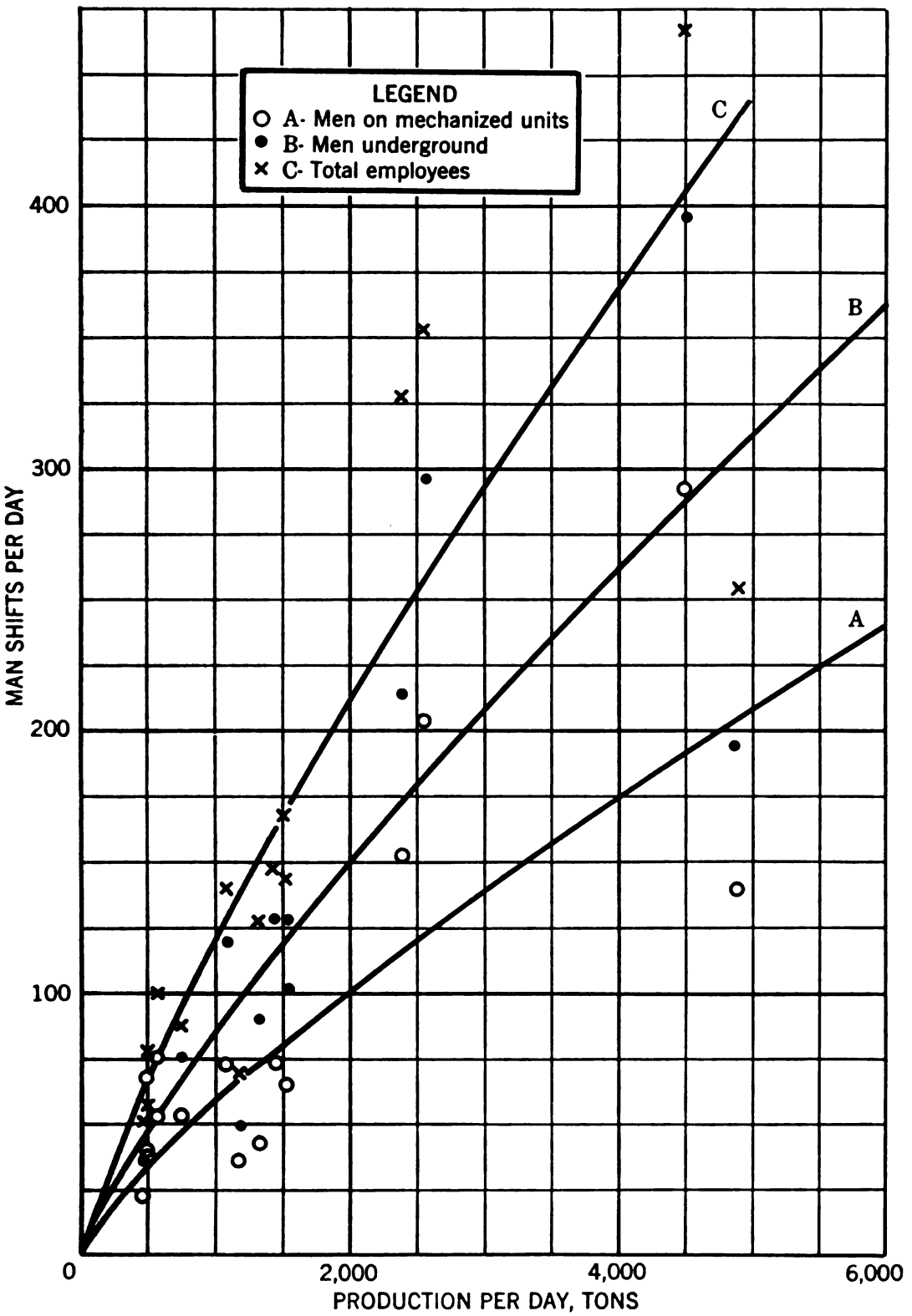

Figure 10.—Man shifts per day and production per day.

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Rise in daily production necessitates an increase in the number of men for transportation, ventilation, and mine and equipment maintenance. The number of men declines from 84 per 1,000 tons for a daily production up to 1,000 tons per day, to 50 men per 1,000 tons in mines producing 4,000 to 5,000 tons per day. Total underground employees include those chargeable to mechanized units; thus, the average number of underground employees, exclusive of those on mechanized units, is 30 per 1,000 tons for the first 1,000 tons per day and 15 per 1,000 tons for 4,000 to 5,000 tons per day. The minimum number of men, exclusive of men in mechanized units, used at the mines included in this report is 11.2 per 1,000 tons daily production. Physical conditions in and surrounding the bed at this mine are excellent, and few men are required to maintain entries and haulageways. A large daily output is made possible by a high percentage of loading time with a small number of loading machines. The maximum of 45.5 men per 1,000 tons, exclusive of men in mechanized units, is at a mine where maintenance of roof and track in haulageways is more than normal for the output of the loading machines.

Curve C, figure 10, is the weighted average curve of all employees underground and surface. This curve indicates that the number of men declines from 120 employees per 1,000 tons for a daily production up to 1,000 tons, to 70 per 1,000 tons for an output of 4,000 to 5,000 tons per day. The number of surface employees depends upon conditions, especially whether the mine is equipped with a cleaning plant. The average number of surface employees ranges from a minimum of 20 to a maximum of 36 employees per 1,000 tons. At the mines described in this report the maximum number of surface men employed per 1,000 tons was 47.3. This mine is not equipped with a washery, and a large number of slate pickers are employed in the preparation plant. The minimum number of men employed per 1,000 tons was 12.7 at a mine where the coal was comparatively free from impurities. The number of men employed on the surface was a minimum for the high daily production.

Table 2 is the summary of performance at the mines investigated in this study where the coal is loaded onto conveyors. The effect of thickness of the coal bed on output per wall-conveyor shift and tons per men on conveyor units is shown by comparing items 10, 11, and 13 at mines 33 and 34. The importance of proper balance between development and face work is also shown by comparing the average of total production per conveyor unit shift, item 10.

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TABLE 2.- Summary of performance of conveyors

Item	Mine 33			Mine 34		
1. Description of mechanization:						
a. Cutting machines, type....	Longwall, shortwall			Longwall		
b. Loading machines, type....	Hand-loading onto conveyors			Hand-loading onto conveyors		
2. Location of mine.....	Arkansas			Alabama		
3. Percent of mine mechanized.....	100			82		
4. Average daily production from mechanized units, tons.....	Walls 912	Dev. 88	Total 1,000	Walls 232	Dev. 106	Total 338
5. Thickness and dip of coal bed..	46 inches, 2-1/2percent			26 inches, irregular		
6. Number and hours of shift in mine.....	2 - 7-hour			2 - 7-hour		
7. Number and hours of shift in tipple.....	1 - 7-hour			1 - 7-hour		
	Walls	Dev.	Total	Walls	Dev.	Total
8. Number of conveyor units.....	4	2	6	2	5	7
9. Number of conveyor-unit shifts per day.....	5	4	9	2	12	14
10. Average production per conveyor unit per shift.....	182	22	111	116	8.8	24.2
11. Average number of men per unit per shift.....	20	2.5	12.2	20.5	3.0	5.5
12. Man-shifts per day on mechanized units.....	100	10	110	41	36	77
13. Average tons per man per day on mechanized units.....	9.12	8.8	9.1	5.67	2.95	4.39
14. Total number of employees underground.....			134			99
15. Average tons per day per man underground.....			7.46			3.42
16. Total number of employees, surface and underground.....			159			110
17. Average tons per day per man employed.....			6.30			3.07
18. Average tons of coal produced per pound of explosive.....			1/			9.0
19. Average tons of coal produced per prop.....			1.0			2/.5
20. Total power consumed per ton of coal, kw.-hr.			1/			3/10.7
21. Size of mine car, tons.....	Belt conveyors					1.5

1/ Not available.
2/ 4.35 tons per crib timber.
3/ Estimated total, including 96 houses and store, 11.8 kw.-hr. per ton.

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TABLE 3.- Summary of performance of mines in Progress Report 3

Mine	Average thickness of bed mined, inches	Average daily production from mechanized units, tons	Tons per unit per shift	Tons per man per day			Remarks
				Men on mechanized units	Men employed underground	Total, surface and underground employees	
Mobile loading machines:							
26	50	475	238	21.6	13.2	9.31	Loading onto conveyors that discharge into mine cars.
27	1/62	755	189	14.2	10.1	8.68	Loading onto conveyors that discharge into mine cars, and also directly into mine cars.
28	108	4,880	488	34.8	25.1	19.1	Dual haulage, loading into shuttle cars and also directly into mine cars.
29	90	1,335	267	31.0	14.8	10.5	Loading into cars.
30	63	1,836	184	18.7	12.4	9.4	Do. 2/
31	67	860	172	17.2	9.5	6.7	Do.
32	67-1/2	3/837	139	14.7	5/10.6	5/7.3	Do.
Conveyors:							
32	67-1/2	4/88	29	9.8	5/10.6	5/7.3	Do.
33	46	1,000	111	9.1	7.5	6.3	Hand loading.
34	26	338	24	4.4	3.5	3.1	Do.

1/ Thickness of bed irregular.
2/ 1 unit loading onto conveyors.
3/ Tonnage from mobile loading machines.
4/ Pit-car loaders considered as conveyors.
5/ Total men chargeable to both mobile and pit-car loaders.

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CONCLUSIONS

Thickness of the coal bed has an important influence upon output of the loading machine. Figure 8 indicates that the rated capacity of the loading machine is rapidly approached with increased thickness of the bed. Larger tonnages per cut from thicker beds result in fewer place changes, and more time is made available for loading. There is also more coal per linear foot of face, and the time required for "squirming" or maneuvering the machines is lessened.

The results of the additional studies of the mines in this report made since the first two investigations were begun 3 years ago indicate that in this interval there has been developed a marked increase in efficiency in handling mobile loading machines, better face preparation and coordination of transportation, with the resultant greater output per man on mechanized unit. At the time Progress Reports 1 and 2 were made the average number of men chargeable to mechanized units was 60 per 1,000 tons daily production. This average has been reduced to 54 men per day for outputs up to 1,000 tons and 35 men per 1,000 tons for outputs of 4,000 to 5,000 tons per day.

An advantage is indicated for loading coal by mobile loading machines onto conveyors in moderately thin beds where roof conditions do not require excessive timbering. This practice allows cars to be loaded in trips on a brushed entry. Thus, larger cars can be used than is possible if cars were taken into rooms for loading; or a number of small cars can be loaded as a unit, and the time lost changing a large number of individual small cars is reduced. The use of a hopper at the inby end of the conveyor, such as that used at mine 30 in the conveyor section, reduces spillage at the loading point and lessens the amount of coal that must be cleaned up by hand. The use of this hopper also increases the area into which the rear conveyor of the loading machine discharges the coal, thus increasing effective loading time and decreasing the time lost in maneuvering the rear conveyor of the loading machine over an exact location.

The atmosphere in the working place is freer from dust where water is used on the coal during cutting and loading. This practice not only reduces the dust hazard but should increase the workers' efficiency.

The study thus far indicates that mobile loading machines are best suited to comparatively level beds with favorable physical conditions. Fragile roof that requires excessive timbering usually results in a slower rate of loading and also reduces the tons per man because of the additional men required with each crew to maintain the working place in safe condition.

Conveyors are adapted to working thin beds, especially in mines using a longwall or long-face system of mining. To obtain maximum tonnage per man, enough entry development should be maintained to permit a high proportion of production from walls. There should be proper balance between wall and development tonnage.

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The advisability of working a mine two shifts a day to obtain optimum results is recognized. For safety of operation, however, the same quantity and quality of supervision should be given on all shifts. The third shift should be used for maintenance of equipment, track extension, timbering, extension of ventilating circuits, and general mine maintenance. The rapid advance of working places that results from mechanized mining on two shifts allows little time during the production shifts for permanent mine maintenance. This work can be done more efficiently and economically on the third shift.

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